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Great Lakes Water Quality: Status Report on the Persistent Toxic Pollutants in the Lake Ontario Basin by the Implementation Committee: Appendix E

Implementation Committee

00295

Great Lakes Water Quality Board

GLC ZZZZZ 673

Report to the International Joint Commission

Report on Great Lakes Water Quality

Appendix E

GREAT LAKES WATER QUALITY

STATUS REPORT ON THE PERSISTENT TOXIC POLLUTANTS IN THE LAKE ONTARIO BASIN BY THE IMPLEMENTATION COMMITTEE

Presented to the
GREAT LAKES
WATER QUALITY BOARD
December 13, 1976.

(Updated - January 21, 1977)

PREFACE

In the fall of 1976, the Great Lakes Water Quality Board directed its Implementation Committee to prepare a report on the current available information related to persistent toxic substances in the Lake Ontario Basin.

This report was presented to the Board in December 1976. The recommendations contained herein were endorsed by the Board and released to the public.

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SUMMARY AND CONCLUSIONS

A group of toxic substances with known or potential adverse effects on aquatic life and public health has been identified in the Great Lakes. Available data from monitoring programs on the distribution and bioaccumulation of these substances in Lake Ontario have been summarized in this report. A significant amount of information exists on the substances that have been of concern in recent years such as Mirex [Dechlorane], PCB, DDT and mercury. This information results from intensive monitoring efforts by environmental agencies in reaction to specific problems that have arisen. However, for other organic substances meeting the criteria of toxicity, persistence, bioaccumulation and presence anywhere in the Great Lakes environment, additional quantitative information is needed on sources and levels of the substances in the environment.

RECOMMENDATIONS

The Implementation Committee recommends the following to the Water Quality Board:

1. Monitoring and laboratory programs in support of the International Great Lakes Surveillance Program in Lake Ontario should be continued at a level sufficient to establish
   (a) trends of toxic substances such as Mirex [Dechlorane], PCBs, DDT and mercury for which some information is available, and
   (b) the significance of the other toxic substances for which only qualitative information is available.
2. Water quality objectives and/or statements indicating a desired absence for a material should be considered for the substances identified in this report.
3. The collection, analysis and dissemination of data on sources and environmental distribution of persistent toxic substances should be extended to the entire Great Lakes system. These data would be gathered by the Surveillance and Remedial Programs Subcommittees.
4. Research should be intensified to determine the pathways, fate and effects of potentially toxic elements. Such efforts will be useful in the further development of surveillance and remedial programs to protect human health, fishery resources and wildlife of the Great Lakes.
5. The environmental health agencies in both countries should consider establishing required action levels for the protection of human health from substances and any combination of toxic substances identified in this report and other toxic substances which may be identified in future.

6. All jurisdictions should proceed to identify raw materials, processes, products, by-products, waste sources and emissions involving, as a priority, persistent toxic organic substances and quantitative data on the substances, together with recommendations on the handling, use and disposition.

7. All jurisdictions should establish close co-ordination between the air, water, and solid waste programs to assess the total input of toxic substances to the Great Lakes system. In particular, additional information is required on the concentrations of toxic substances in the atmosphere and the mechanism of transport to the water environment.

BACKGROUND OF THE STUDY

At the September 1976 meeting of the Water Quality Board, the issue of toxic materials in Lake Ontario was discussed at some length with particular emphasis on the immediate problems relating to mirex, kepone, PCBs and other identified pesticides. The State of New York suggested to the Water Quality Board that a reference or work group be established to address the following areas:

1. Review of available data on the distribution and bioaccumulation of toxic materials.

2. Coordination of future programs to assess the degree of contamination of Lake Ontario.

3. Recommendations regarding future data collection, financial and technical assistance to conduct necessary programs and measures to protect the public health and resources of Lake Ontario.

In response to the State of New York's suggestion, the Water Quality Board directed the Implementation Committee to review the available data on the distribution and bioaccumulation of toxic materials in Lake Ontario. It also directed the Committee to investigate the feasibility of utilizing the existing committee structure of the Board to undertake items #2 and #3.

APPROACH AND ACTION TAKEN BY THE IMPLEMENTATION COMMITTEE

On October 8, 1976, the Implementation Committee called a special meeting of technical experts from U.S. EPA, State of New York, Environment Canada and Environment Ontario to assist it in establishing the foundation for a thorough review of available data and information on the distribution and bioaccumulation of toxic materials in Lake Ontario. The group recognized that there are numerous lists of toxic substances currently being considered or examined by various environmental and health agencies in both countries and that the first step should be to determine which toxic materials are to be considered for the data collection effort. It was the opinion of the experts and Committee members present at the meeting that four lists of toxic substances should be prepared from the existing numerous lists which have been developed and supplied by the various agencies. In this manner, the resources and expertise of the agencies are utilized. In order to organize the lists to a manageable size, the following four criteria are considered:

Criterion 1: The toxic substances must be identified in the biota, rainwater, effluents, etc.

Criterion 2: There is evidence of bioaccumulation as determined by such indices as the partition coefficient.

Criterion 3: The substances must be toxic to either fish, man or wildlife or be a mutagen, carcinogen, or teratogen.

Criterion 4: The substances must be persistent.

The first list (List #1) consists principally of the revised or new water quality objectives recommended by the Water Quality Board to the Commission for adoption. Several other substances of immediate concern are included. Chemicals on this list meet all four criteria.

The second list (List #2) is derived from the following sources:

- O A general list of problem substances drawn up by the Environmental Contaminants Control Branch of Environment Canada based upon inventories of those chemicals which are presently being studied or have been designated as hazardous or toxic by such organizations as EPA, NIOSH, WHO and NRC Canada.

- O A list of pollutants forming part of a court settlement Agreement between U.S. EPA and the Natural Resources Defense Council dated June 7, 1976.

- O A list of substances which may cause chronic health effects as a result of exposure to a low concentration over a long period of time. The list was supplied by the Ontario Ministry of the Environment.

List #2 consists of those substances from the above sources which meet all four criteria. The remaining substances from the above sources which do not meet all four criteria will constitute a third list (List #3).

The fourth list (List #4) will consist of toxic substances which are known to be used, manufactured or discharged in the Great Lakes.

First two of the four toxic substances (Lists #1 and #2) lists have been prepared and are shown in Tables I and II. While this report deals only with Lake Ontario, the toxic substances identified here are applicable to the entire Great Lakes Basin. Current availability of data for these substances in Lake Ontario is also indicated in the Tables. The lists may change as more data become available.

OBJECTIVES OF THE STUDY

This report is prepared with the following objectives:

1. To consolidate all the available information and data on the bioaccumulation and distribution of certain toxic substances in Lake Ontario.

2. To present a general overview of the toxic pollutant problems in Lake Ontario.

3. To identify information gaps where they occur and make recommendations.

4. To establish an information baseline on which future data collection on toxic materials can be based.

5. To relate the presence of toxic materials to possible sources and remedial or preventative actions.

This work should lead to the determination of the quantitative significance for aquatic life and human health of the toxic substances identified in this report and establishment of action levels where human consumption of fish is involved.

OVERVIEW OF LAKE ONTARIO FISH DATA AND ACTION LEVELS

Table III shows an overview of the available data on toxic substances identified in this report for which U.S. action levels or Canadian guidelines have been established. The ranges of concentrations in Lake Ontario fish for Mirex, PCBs, DDT, mercury, heptachlor, endrin, aldrin/dieldrin and arsenic are presented. The recommended or proposed water quality objectives for the Agreement are also included. The maximum values for Mirex, PCBs and mercury exceed those U.S. action levels and Canadian guidelines for human consumption. The maximum concentrations reported for mercury, DDT and PCBs in edible tissues also exceed the Agreement objectives for whole fish samples. While the values in the Table represent a wide range of fish species, number of samples analysed, age, size and sex, and the portion of sample considered as edible tissue may vary, the fact that certain substances in Lake Ontario fish approach or exceed levels considered unsuitable for human consumption must be a matter of concern. Furthermore, it is known generally that a compound which undergoes bioaccumulation and biomagnification will have whole body levels greater than those in edible tissues because of greater accumulation in lipids, nervous tissues and other body organs. This means that for the several substances reported in the edible fish tissues, higher levels could be expected in the whole fish.

TABLE I

PERSISTENT TOXIC SUBSTANCES (LIST #1)

TOXIC SUBSTANCES \ MEDIA	POINT SOURCES	ATMOSPHERIC SOURCES	SEWAGE SLUDGE	RUNOFFS	SEDIMENTS	WATER QUALITY AND MONITORING	BENTHOS AND PLANKTON	FISH	WILDLIFE
<u>Organic Substances</u>:									
Aldrin/Dieldrin		X			X	X	X	X	X
Chlordane		X			X	X	X	X	X
DDT and Metabolites		X			X	X	X	X	X
Endrin					X	X	X	X	
Heptachlor					X	X	X		
Heptachlor epoxide		X			X	X	X	X	X
Lindane		X			X	X	X		
Methoxychlor		X			X	X	X		X
Toxaphene								X	
Phthalic Acid Esters									
Polychlorinated Biphenyls	X	X	X	X	X	X	X	X	X
Kepone									
C_{10} Cl_{12} (Mirex and Dechlorane)	X				X	X		X	X
<u>Inorganic Substances</u>:									
Arsenic	X	X			X	X		X	
Cadmium	X	X			X	X			
Lead	X	X			X	X		X	
Mercury	X	X			X	X		X	X
Selenium		X				X		X	
Zinc		X			X	X			

X indicates that qualitative or quantitative data can be found in this report.

TABLE II: PERSISTENT TOXIC SUBSTANCES (LIST #2)

TOXIC SUBSTANCES \ MEDIA	POINT SOURCES	ATMOSPHERIC SOURCES	SEWAGE SLUDGE	RUNOFFS	SEDIMENTS	WATER QUALITY AND MONITORING	BENTHOS AND PLANKTON	FISH	WILDLIFE
Organic Substances:									
Benzene		X							
1,2 - 1,3 -, 1,4 - dichlorobenzenes	X								
Trichlorobenzene								X	
Tetrachlorobenzene								X	
Pentachlorobenzene								X	
Hexachlorobenzene HCB		X						X	X
p - bromoanisole		X							
Chlorinated naphthalene		X							
Methylnaphthalene	X								
Phenol	X					X			
Trichlorophenol						X			
Pentachlorophenol						X			
Tetrachlorophenol						X			
Carbon tetrachloride	X	X							
Chloroform	X	X							
Bromoform									
Tetrachloroethylene	X								
Chlorinated Styrenes (Octa & Poly)								X	
Hexachlorobutadiene (HCBD)									
Toluene		X							
Pentabromotoluene									
2,3,7,8 - tetrachlorodibenzo -p- dioxin (TCDD)									
BHC (1,2,3,4,5,6 - hexachlorocyclohexane)									
β - BHC (Benzene hexachloride)									X
Polybrominated Biphenyls	X					X		X	
Chlorinated terphenyls									
Polynuclear Aromatic Hydrocarbons		X			X				X
Inorganic Substances:									
Nickel		X			X	X			
Copper		X			X	X			
Iron		X			X	X			
Chromium					X	X			

X indicates that qualitative or quantitative data can be found in this report.

TABLE III

SUMMARY OF U.S. AND CANADIAN DATA FOR SELECT TOXIC SUBSTANCES IN LAKE ONTARIO

	ACTION LEVELS AND GUIDELINES (µg/g) Edible Portion of Fish Unless Otherwise Specified			RANGE OF LEVELS IN LAKE ONTARIO	
	U.S.	CANADA	PROPOSED OR RECOMMENDED AGREEMENT OBJECTIVE	Fish (µg/g) [Edible Portion Unless Otherwise Specified]	Water (µg/ℓ)
Mirex	0.1		Being developed.	0.002 - 1.3	
PCBs	5.0	2	0.1 µg/g whole fish and wet weight	0.008 - 22.5	
DDT	5.0	5	1.0 µg/g whole fish and wet weight	0.01 - 4.08	
Mercury	0.5	0.5	.2 µg/ℓ in water .5 µg/g whole fish and wet weight	<0.05 - 1.99	0.05 - 0.07
Heptachlor	0.3		.3 µg/g edible portion	0.001 - .003	
Endrin	0.3		.3 µg/g edible portion	<0.001 - 0.003	
Aldrin/Dieldrin	0.3		.3 µg/g edible portion	<0.001 - 0.016	
Toxaphene	5.0		.008 µg/ℓ in water		
Kepone	0.1				
Lead		10 marine & fresh water animal products	10 µg/ℓ Lake Superior 20 µg/ℓ Lake Huron 25 µg/ℓ All others		1.0 - 2.0
Arsenic		5.0 marine & fresh water animal products	50 µg/ℓ in water	0.05 - 0.07 (whole fish and wet weight)	0.2 - 1.2
Lindane	.3		.3 µg/g edible portion .01 µg/ℓ in water		<0.005 - 0.008

1. DATA ON POINT SOURCES

A review of the New York State NPDES/SPDES permit file was conducted to identify industrial dischargers of toxic substances for which parametric effluent limits have been established. The attached Table 1.1 lists these sources with their current discharge loadings. Permittees have been requested to provide additional data for specific substances which are present in discharges covered by the existing permit limits.

A questionnaire mailing is currently underway to approximately 5,000 industries which have been identified as potential toxic substance users or producers. The majority of these industries discharge to municipal collection systems. Industries have been identified using the Standard Industrial Classification Code as shown in Table 1.2. All industries are being asked to respond to the questionnaire contained in Table 1.3.

In Ontario, several organics have been identified in industrial effluents (Table 1.4) located in the Lake Ontario Basin. There are also regular monitoring of industrial wastes for mercury, lead, arsenic and cadmium.

Specifically for PCBs, there are numerous minor sources of discharges. Because of the quantities involved, the greatest potential for loss is within the electrical industry via losses during the manufacture, sale, distribution, use and ultimate disposal of electrical equipment containing PCB.

Municipal sewage treatment plants, electrical equipment manufacturers, industries using PCB as heat transfer or hydraulic fluids and paper recycling plants have all been identified as sources of discharge. However, the quantities involved are unlikely to be sufficient to account for the estimated quantities in sediments and waters in the Ontario environment. PCBs data collected on municipal wastewaters and industrial effluents are shown in Tables 1.5 and 1.6. Estimated 1974 PCBs loadings for certain municipal plants in the Lake Ontario basin are shown in Table 1.7.

Borg-Warner Canada Limited in Cobourg, Ontario had used PBB in one of its minor manufacturing processes. Samples of raw wastewater and treated effluent taken at the Cobourg plant indicated 0.7 ppb and 0.01 ppb of Polybrominated Biphenyls.

High levels of PCB in sewage in Toronto, Peterborough and Hamilton are likely the result of past or present disposal practices at transformer and capacitor manufacturing plants in these municipalities. Other potential sources of direct discharge into sewerage systems may be disposal of quantities of PCB insulating oil removed from industrial and public utility transformers for routine checking, and the losses from industrial hydraulic and heat transfer systems containing PCBs.

The Great Lakes Water Quality Board Annual Reports also contain data on point source discharges of phenols in Lake Ontario.

TABLE 1.1

INDUSTRY	PARAMATER	EFFLUENT LIMITS (lbs./day)		DISCHARGE (lbs/day)
		Initial	Final	
Hooker Chem. & Plastics Co., Niagara Falls				
Outfall #2	Chlorinated Hydrocarbons	250 (Avg.)	250 (Avg.)	231.5 (Avg.)*
All Outfalls	Mercury	.200 (Avg.)	.200 (Avg.)	.058 (Avg.)
Fisher-Price Toys Holland	Chlorinated Hydrocarbons	5.0 (Max.)	5.0 (Max.)	.00032 (Max.)
Stauffer Chemical Co. Niagara Falls	Carbon Disulfide	None	250 (Avg.)	<.03 (Avg.)
Allied Chemical Corp. Geodes (T)	Tetrachloroethylene	No Limits		2.89 +
	Tetrachloromethane (Carbon Tetrachloride)	No Limits		2.48 +
	Dichlorobenzene	No Limits		0.34 +
	Other Chlorinated Hydrocarbons	No Limits		12.93 +

* Average chlorinated hydrocarbon discharge for August 1976 was 10 lbs/day

\+ Average of 5 samples

Remaining discharge loadings based on Monitoring reports from the waste sources for the Water Year October 1, 1975-September 30, 1976.

Source: NYDEC

TABLE 1.2

STANDARD INDUSTRIAL CLASSIFICATION CODES FOR LIKELY USERS OR PRODUCERS OF HALOGENATED ORGANICS OR SUBSTITUTED AROMATICS

INDUSTRY	SIC CODE
1. Asphalt & Asphalt Products	2952
2. Chemicals - Industrial	281X, 286X
3. Chemicals - Miscellaneous	289X
4. Foundaries - Ferrous & Non-ferrous	332X, 336X
5. Linoleum, Floor Tile	3996
6. Lubricating Oils & Greases	2992
7. Paints, Varnishes, Lacquers, & Allied Products	285X
8. Paving & Roofing Material	2951
9. Pesticides	2879
10. Petroleum Refining & Miscellaneous Petroleum Products	2911
11. Plastics Products - Miscellaneous	3079
12. Plastic Material & Synthetic Resin, Rubber & Fibers	282X
13. Rubber & Rubber Products	301X - 306X
14. Textile Goods - Miscellaneous	229X
15. Textile Products - Fabricated	239X
16. Abrasive Products	3291
17. Blast Furnaces	331X
18. Pulp & Paper	261X - 266X
19. Dyeing & Finishing of Textiles	226X
20. Foods	203X, 209X
21. Leather Tanning & Finishing	3111
22. Meat Products	201X
23. Petroleum Refining	2911
24. Beverages	2086-7

SOURCE: New York Department of Environmental Conservation

TABLE 1.3 (a)

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NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
ALBANY, NEW YORK 12233

INDUSTRIAL CHEMICAL SURVEY

PART I

PLEASE COMPLETE AND RETURN TO THE ABOVE ADDRESS, ATTENTION: INDUSTRIAL CHEMICAL SURVEY.

COMPANY NAME		SIC CODE (If known)	OFFICE USE ONLY
COMPANY MAILING ADDRESS	CITY	STATE	ZIP CODE
PLANT NAME (If different)	CONTACT NAME		TELEPHONE Area
PLANT ADDRESS (If different) Street	CITY	STATE	ZIP CODE
PRINCIPAL BUSINESS OF PLANT			

NOTE: (If parent company, give name and addresses of all divisions, subsidiaries, etc. located in New York State. A separate questionnaire is to be completed and submitted for each.)

PART II
Discharge Information

WATER

1. Does your plant discharge liquid wastes to a municipally owned sanitary sewer system? ☐ Yes ☐ No
   Name of System ______
2. Is your facility permitted to discharge liquid wastes under a State (SPDES) or Federal (NPDES) permit? Permit Number ☐☐☐☐☐☐☐ ☐ Yes ☐ No
3. Do you discharge liquid wastes in any other manner? ☐ Yes ☐ No
   Explain ______

If any of the above are "Yes":
a. Do you discharge process or chemical wastes – (i.e. water used in manufacturing including direct contact cooling water and scrubber water)? ☐ Yes ☐ No
b. Do you discharge non-contact cooling water? ☐ Yes ☐ No
c. Do you discharge collected storm drainage only? ☐ Yes ☐ No
d. Do you discharge sanitary wastes only? ☐ Yes ☐ No

AIR

1. Does your facility have sources of possible emissions to the atmosphere? ☐ Yes ☐ No
2. Enter Location and Facility Code as shown on your Air Pollution Control Application for Permits and Certification (If applicable) ☐☐☐☐☐☐☐☐☐☐

SOLID & CONCENTRATED LIQUID WASTES

1. List Name and Address of Firm (Including yourself) removing wastes other than office and cafeteria refuse.

Name			
Address	City	State	Zip Code
Name			
Address	City	State	Zip Code

2. List Location(s) of Landfill(s) owned and used by your facility.

		Active	Inactive
1		☐	☐
2		☐	☐

PESTICIDES

1. Does this facility:
   Manufacture Pesticides or Pesticide Product Ingredients? ☐ Yes ☐ No
   Produce Pesticides or Pesticide Product Ingredients? ☐ Yes ☐ No
   Formulate Pesticides? ☐ Yes ☐ No
   Repackage Pesticides? ☐ Yes ☐ No
2. EPA Establishment Number ☐☐☐☐☐ – ☐☐ – ☐☐☐

PART III TABLE 1.3 (b)

SUBSTANCES OF CONCERN
(Refer to attached TABLE)

Complete all information for those substances your facility has used, produced, stored, distributed or otherwise disposed of since January 1, 1971. Do not include chemicals used only in analytical laboratory work. Enter the name and code from Table I. If facility uses a substance in any of the Classes A – F which is not specified in the list, enter it as code class plus 99, e.g. B99 with name, usage, etc.

NAME OF SUBSTANCE	CODE	AVERAGE ANNUAL USAGE	AMOUNT NOW ON HAND	(✓) GAL.	(✓) LB.	PURPOSE OF USE (State whether produced, reacted, blended, packaged, distributed, no longer used, etc.)

If you use chemicals of unknown composition, list trade name or other identification, name of supplier and complete information.

NAME OF SUBSTANCE	AVERAGE ANNUAL USAGE	AMOUNT NOW ON HAND	(✓) GAL.	(✓) LB.	SUPPLIER	PURPOSE OF USE (State whether produced, reacted, blended, packaged, distributed, no longer used, etc.)

I hereby affirm under penalty of perjury that information provided on this form is true to the best of my knowledge and belief. False statements made herein are punishable as a Class A misdemeanor pursuant to Section 210.45 of the Penal Law.

SIGNATURE (Owner, Partner, or Officer)	DATE

NAME (Printed or Typed)	TITLE

CLASS A – HALOGENATED HYDROCARBONS

A01. Methyl chloride
A02. Methylene chloride
A03. Chloroform
A04. Carbon tetrachloride
A05. Freon/Genatron
A06. Other halomethanes
A07. 1, 1, 1-Trichlorethane
A08. Other haloethanes
A09. Vinyl fluoride
A10. Vinyl chloride
A11. Dichloroethylene
A12. Trichloroethylene
A13. Tetrachloroethylene
A14. Chlorinated propane
A15. Chlorinated propene
A16. Hexachlorobutadiene
A17. Hexachlorocyclopentadiene
A18. Chlorinated benzene
A19. Chlorinated toluene
A20. Fluorinated toluene
A21. Polychlorinated biphenyl (PCB)
A22. Chlorinated naphthalene
A23. Dechlorane ($C_{10}Cl_{12}$)
A24. Hexachlorocyclohexane (BHC)

A99. Halogenated hydrocarbons not specified above

CLASS D – AROMATIC HYDROCARBONS

D01. Benzene
D02. Toluene
D03. Xylene
D04. Biphenyl
D05. Naphthalene
D06. Ethylbenzene
D07. Styrene
D08. Acenaphthene
D09. Fluoranthene

D99. Aromatic hydrocarbons not specified above

CLASS E – TARS

E01. Coal tar
E02. Petroleum tar

E99. Tars not specified above

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CLASS B – HALOGENATED ORGANICS (other than hydrocarbons)

B01. Phosgene
B02. Methyl chloromethyl ether
B03. bis-chloromethyl ether
B04. Other chloroalkyl ethers
B05. Benzoyl chloride
B06. Chlorothymol
B07. Chlorinated phenol
B08. Chlorinated cresols or xylenols
B09. Chlorendic acid
B10. Chloroaryl ethers
B11. Dichlorophene or hexachlorophene
B12. Chlorinated aniline (including methylene bis (2-chloroaniline))
B13. Dichlorobenzidine
B14. Chlorinated diphenyl oxide
B15. Chlorinated toluidine
B16. Kepone ($C_{10}Cl_{10}O$)
B17. Dichlorovinyl sulfonyl pyridine
B18. Chloropicrin
B19. Trichloromethyl thio-phthalimide
B20. Trichloro-propylsulfonyl pyridine
B21. Tetrachloro-methylsulfonyl pyridine
B22. Tetrachloro-isophthalonitrile

B99. Halogenated organics not specified above

CLASS F – SUBSTITUTED AROMATICS (other than hydrocarbons and non-halogenated)

F01. Phenol, cresol, or xylenol
F02. Catechol, resorcinol, or hydroquinone
F03. Nitrophenols
F04. Nitrobenzenes
F05. Nitrotoluenes
F06. Aniline
F07. Toluidines
F08. Nitroanilines
F09. Nitroanisole
F10. Toluene diisocyanate
F11. Dimethylaminoazobenzene
F12. Benzoic Acid (and Benzoate salts)
F13. Phthalic, isophthalic or terephthalic acid
F14. Phthalic anhydride
F15. Phthalate esters
F16. Phenoxyacetic acid
F17. Phenylphenols
F18. Nitrobiphenyls
F19. Aminobiphenyls (including benzidine)
F20. Diphenylhydrazine
F21. Naphthylamines
F22. Carbazole
F23. Acetylaminofluorene
F24. Dyes and organic pigments
F25. Pyridine

F99. Substituted aromatics not specified above

CLASS C – PESTICIDES (includes herbicides, algaecides, biocides, slimicides and mildewcides)

C01. Aldrin/Dieldrin
C02. Chlordane and metabolites
C03. DDT and metabolites
C04. Endosulfan/Thiodan and metabolites
C05. Endrin and metabolites
C06. Heptachlor and metabolites
C07. Malathion
C08. Methoxychlor
C09. Parathion
C10. Toxaphene
C11. Sevin
C12. Kelthane
C13. Diazinon
C14. Dithane
C15. Carbaryl
C16. Silvex
C17. Dithiocarbamates
C18. Maneb
C19. Dioxathion
C20. Tandex/Karbutilate
C21. Carbofurans
C22. Pentac
C23. Folpet
C24. Dichlone
C25. Rotenone
C26. Lindane/Isotox
C27. Simazine
C28. Methoprene

C99. Pesticides not specified above

CLASS G – MISCELLANEOUS

G01. Asbestos
G02. Acrolein
G03. Acrylonitrile
G04. Isophorone
G05. Nitrosamines
G06. Ethyleneimine
G07. Propiolactone
G08. Nitrosodimethylamine
G09. Dimethyl hydrazine
G10. Maleic anhydride
G11. Methyl isocyanate
G12. Epoxides
G13. Nitrofurans

TABLE 1.4

ORGANICS IDENTIFIED IN INDUSTRIAL EFFLUENTS IN LAKE ONTARIO

BORG WARNER - Cobourg	
- tetrachloroethylene - acrylonitrile - butadiene - cumene	discharged to Lake Ontario
CORNWALL CHEMICALS - Cornwall	
- benzaldehyde - benzephenone	discharge to Domtar effluent and treatment system to St. Lawrence River
F.M.C. OF CANADA LTD. - Burlington	
- endosulfan (suspected - analysis not completed)	discharge to sewage treatment plant to Hamilton Harbour

SOURCE: Ontario Ministry of the Environment, 1976.

TABLE 1.5

PCB'S IN WASTEWATERS FROM SELECTED ONTARIO MUNICIPALITIES - 1975

LOCATION	AVERAGE FLOW (MIGD)	*PCB CONCENTRATION (ppb)
Cornwall	10.0	0.05
Brockville	3.0	0.09
Kingston	11.9	0.05
Belleville	7.0	ND
Trenton	2.0	0.06
Cobourg	3.0	ND
Oshawa	9.0	ND
Toronto East	180.0	ND
Toronto Humber	63.0	0.57
Clarkson	9.0	ND
Oakville	6.0	0.40
Burlington	8.0	0.30
Hamilton	52.0	0.10
Port Weller	8.5	0.03
St. Catherines	9.0	ND
Port Colborne	1.2	0.10

*Concentration represents a mean of two analyses.

SOURCE: "Polychlorinated Biphenyls in the Ontario Environment", MOE Report, July 1976.

TABLE 1.6

PCB'S IN SELECTED INDUSTRIAL EFFLUENTS - 1975/76

LOCATION	COMPANY	DATE SAMPLED	EFFLUENT TYPE	DAILY DISCHARGE (Litres)	PCB CONC. (µg/ℓ)	EST. DAILY PCB LOADING (grams)	EST. ANNUAL* LOADING (grams)	DISCHARGED TO
St. Catherines	General Motors							
	Plant #1	Nov. 18/75	Cooling Water	4,500,000	2.60	11.70	2,925	Twelve Mile Creek
	Plant #1	Nov. 18/75	Process Water	1,500,000	0.35	0.53	133	Sewage Treatment Plant
	Plant #2	Nov. 18/75	Process Water	109,200,000	0.15	16.38	4,095	Welland Canal
	Plant #2	Feb. 23/76	Process Water		0.20			
St. Catherines	Ferranti Packard	Nov. 18/75	Final Effluent		3.20			
		Nov. 18/75	Final Effluent	514,000	0.90	0.46	115	Sewage Treatment Plant

*Based on 250 working days

SOURCE: "Polychlorinated Biphenyls in the Ontario Environment", MOE Report, July 1976.

TABLE 1.7

ESTIMATED INFLUENT AND EFFLUENT PCB'S LOADINGS FOR WASTEWATER TREATMENT PLANTS IN SELECTED ONTARIO MUNICIPALITIES 1974

LOCATION	LOADING (kg/yr)	
	Influent	Effluent
Burlington	19.9	1.3
Elmira	0.2	0.2
Grimsby	0.03	0.03
Hamilton	154.1	25.8
Kingston City	5.9	3.9
New Hamburg	0.1	0.03
Niagara-on-the-Lake	0.3	0.1
Oakville	2.0	1.0
Oshawa	1.0	1.0
Peterborough	14.9	1.5
Port Dover	0.6	0.2
Toronto - Main	165.9	119.2
Toronto - Humber	62.6	41.7
Toronto Highland	3.1	3.1
Toronto North	1.5	1.5
Waterdown	0.02	0.02
Welland	1.2	1.2

Source: "Polychlorinated Biphenyls in the Ontario Environment", MOE Report, July 1976

MIREX

On the U.S. side of Lake Ontario, there appears to be two major sources of mirex to the lake, one in the Niagara River area, and one in the Oswego River area.

The only Niagara River source thus far identified is the Hooker Chemical Company, Niagara Falls, New York. The United States Environmental Protection Agency (U.S. EPA) and NYDEC carried out a preliminary sampling program for mirex at the Hooker plant on July 13, 1976. The results of the sampling program indicated that, despite the fact that Hooker has not produced mirex since 1967 and has not ground or packaged it since April 1975, there is still an apparent discharge to the Niagara Falls municipal sanitary sewer system. Traces were also found in cooling water outfall which formerly served the mirex manufacturing and grinding areas.

A comprehensive sampling program was carried out from September 28 to 30, 1976 at the Hooker plant site. The survey team included personnel from NYDEC, U.S. EPA and Hooker Chemical Company. Fourteen points within the Hooker plant site were sampled on three consecutive days and analyzed for mirex. These sample sites included the 4 direct discharges to the Niagara River and the connection to the City of Niagara Falls collection system. Extracts of all samples will be retained by the three laboratories involved for further analysis of targeted substances and rechecking if necessary. It was the consensus of all parties in the sampling program that mirex was not confirmed to be present in any of the samples.

A sediment sampling program in the Oswego River has confirmed that mirex was (or is) discharged to the Basin. An effluent sampling program is presently underway to locate the source(s).

In Ontario, two firms in the Lake Ontario Basin have purchased Dechlorane from Hooker:

Names	Purchase Period	Amount Purchased
Presstite, Georgetown	1963-68	287,000 lbs.
Northern Electric, Kingston	1965	3,060 lbs.

Investigations have begun to determine if Presstite's activities are causing contamination problems in the vicinity of the two Georgetown disposal sites and the plant itself.

Northern Electric in Kingston has been contacted as well as other associated companies in the area. The 3060 lbs. of mirex sold to Northern Electric were sent to their Lachine, Quebec plant where they were used primarily in experimental formulations for cable insulation. Environment Canada in Quebec is following the matter up and will trace the fate of the waste material.

TABLE 1.8

MONITORING EFFORTS AT HOOKER CHEMICAL COMPANY AS OF OCTOBER 1976

DATE	COLLECTED BY	LABORATORY	PURPOSE	REMARKS
Nov. 15, 1974	EPA; DEC	EPA	To determine magnitude of Mirex discharge.	A possible discharge of up to 2 lbs/day was identified.
Aug.-Sept. 1976	Hooker Chem. Co.	Hooker Chem. Co., Univ. of Miss.	" " "	Discharge rate was less than 0.1 lbs/day.
Sept.27-30, 1976	EPA; DEC; Hooker	EPA; Hooker; Univ. of New Orleans	" " "	Awaiting results.

SOURCE: New York Department of Environmental Conservation.

2. DATA ON ATMOSPHERIC SOURCES

Environment Canada has been monitoring the chemical composition of precipitation in the Great Lakes Basin since 1969. Trace metal data from 6 monitoring stations in the Lake Ontario Basin are shown in Table 2.1. Concentration levels of these trace metals in precipitation are generally higher than found in lake water. In 1976 a special sampling project for trace organic contaminants in precipitation was initiated. The limited data that are presently available from this project show that the following substances were regularly found in rain-water in the Lake Ontario area:

Lindane	DDT residues	Dieldrin
Methoxychlor	α, β-endosulfan	cis-, trans-chlordane
some PCBs		

There were also tentative identifications of Mirex and BHC. More definitive conclusions about the presence of these substances and their concentration levels in rain-water will be made when a more complete data base becomes available.

The Air Resources Branch of the Ontario Ministry of the Environment has an ambient air sampling program to monitor polycyclic aromatic hydrocarbons (PAH) near the suspected sources in several Ontario cities. The program will include an inventory of PAH emissions in Ontario, evaluation of emission control methods, and the preparation of a comprehensive background report summarizing ambient air and source testing data and other information pertinent to the Ministry's standards setting and monitoring activities. Information on health effects will be obtained from the Ministry of Health. This program is expected to be completed by spring 1977.

In a study for PLUARG, rainfall samples have been collected at certain agricultural watersheds and analyzed for PCBs (Table 2.2). Other preliminary information from rain-water samples indicates that PCBs are present at about 0.02 ppb based on four samples (three from Hamilton Harbour and one from Wisconsin) (see Report of the PCB Task Force). The implication from this preliminary work is that rain-water is a very significant source of PCB to the aquatic environment, particularly to the Great Lakes.

Inefficient combustion of liquid and solid wastes containing PCB will result in the vapourization of PCB into the atmosphere. Conventional multiple hearth sewage sludge incinerators may be inadequate to destroy PCB residues in these sludges. This is being reviewed by the Province.

A report (ORF 72-1) by the Ontario Research Foundation issued on October, 1972 described reliable sampling and analytical techniques and a few quantitative measurements of PCBs at two sites. The ambient air concentration of PCB (as Arochlor 1254, Monsanto's commercial mixture) at a site near the Hamilton municipal incinerator ranged from 4 to 47 ng/m^3 ($\mu g/1000m^3$) and at a site on the ORF roof (non-urban, light industrial) from 0.8 to 8 ng/m^3. Both particulate and vapour-phase PCB were collected and measured by the methodology. These fragmentary results suggested that the disposal of PCB-containing materials by incineration might be a source of emissions to the atmosphere.

TABLE 2.1

TRACE METAL IN PRECIPITATION FROM 6 MONITORING STATIONS

	No. of Samples	% of Samples with values above detection limit	Minimum Value μg/ℓ	Maximum Value μg/ℓ	Mean Value μg/ℓ
Arsenic	17	90	<0.1	2.5	0.8
Cadmium	57	98	0.2	6.0	1.0
Lead	57	96	2	380	35
Selenium	17	100	0.5	1.0	0.5
Zinc	57	98	2	820	87
Copper	57	100	1.5	100	9
Nickel	57	93	1	17	3
Iron	57	100	4	3200	172

SOURCE: Canada Centre for Inland Waters

TABLE 2.2

RESIDUE OF PCB IN RAINFALL, 1975

Watershed	Collection Dates & PCB Residues (ppb) 27 May -23 June	24 June -28 July	29 July -03 September
Big Creek, Essex	0.06	0.05	0.05
Little Ausable, Huron	0.04	0.05	0.10
Upper Canagagigue, Wellington	0.01	0.05	0.07
Middle Thames, Oxford	0.05	ND	0.10
Twenty Mile Creek Niagara N.	0.02	0.08	0.05
Hillman Creek, Essex	0.03	0.06	0.07

SOURCE: Polychlorinated Biphenyls in the Ontario Environment. MOE Report, July 1976.

Further studies (ORF Report 75-1) of PCB levels at Sheridan Park, Hamilton and Toronto over the period April, 1974 to January, 1975 were carried out. Particulate (Hi-Vol filter extract) and vapour-phase (impinger extract) PCB were reported separately. At Hamilton, particulate PCB ranged from 0.3 to 0.4 ng/m^3 and vapour-phase PCB ranged from 2 to 8 ng/m^3. At Toronto, particulate PCB ranged from 0.3 to 3 ng/m^3 and vapour-phase PCB from 0.9 to 2.6 ng/m^3. The ratio of PCB in the vapour-phase to that in the particulate-phase ranged from 2 to 20 over various samples taken at the three sites on different days. PCBs were found predominantly in the vapour-phase and cannot be quantitated by extracting Hi-Vol filters (particulate) alone.

In New York, the Division of Air Resources of the State Department of Environmental Conservation maintains a computerized file of all industrial process emissions to the ambient air of the State. Emissions are classified into over 150 categories according to Table 2.3. The emission rates are submitted by the source owners and reviewed by the State. Such data constitute the sole basis of the emissions information used herein. Present estimates are that 75 percent of all sources are included in the inventory and that only a few major emitters are not. Twenty-two sources of aromatic halogen compounds have been estimated to have a statewide annual emissions of 170,250 pounds. Depending on the assumption made as to what fraction of the emitted pollutant is deposited in the Lake Ontario Basin, the annual loadings to the lake range from 39,500 to 148,300 pounds.

Table 2.4 shows rough estimates of the amounts of certain aliphatic halogen compounds entering Lake Ontario. An air emission inventory for the New York counties in the Lake Ontario drainage basin is presented in Table 2.5 for various specific substances.

There have been other limited special sampling studies for Benzo-a-pyrene, a component of coal tar volatiles, which has been performed around the coke ovens in Buffalo and Lackawanna. A limited study of ambient vinyl chloride samples around the Goodyear Niagara Falls plants has also been performed. Reports on Benzo-a-pyrene, trace metals and vinyl chloride have not yet been completed.

TABLE 2.3

CLASSIFICATION OF AIRBORNE CONTAMINANTS IN NEW YORK

CODE	
	PARTICULATES
	Solid (Free or Combined)
005	Aluminum
010	Arsenic
015	Barium
020	Beryllium
025	Boron
030	Cadmium
035	Chromium
040	Copper
045	Iron
050	Lead
055	Manganese
060	Mercury
065	Selenium
070	Zinc
075	Particulates (non-specific)
	Liquid
080	Nitric Acid Mist
085	Nitrous Acid Mist
086	Chromic Acid Mist
090	Oil Mist
100	Sulfuric Acid Mist
101	Sodium Hydroxide
103	Acid Mist NEC
104	Basic Mist NEC
105	Liquid Mist NEC
	Miscellaneous
110	Asbestos
120	Radioactive Solids
130	Silica
140	Talc
144	Acid Solids NEC
145	Basic Solids NEC
	INORGANIC GASES
	Halogens (Free or Combined)
150	Bromine
155	Hydrogen Bromide
160	Chlorine
165	Hydrogen Chloride
170	Fluorine
175	Hydrogen Fluorine
180	Iodine
185	Hydrogen Iodide
190	Other Inorganic Halogen Gases
	Nitrogen Compounds
200	Nitric Oxide
205	Nitrogen Dioxide
210	Oxides of Nitrogen
	Sulfur Compounds
220	Carbon Disulfide
230	Hydrogen Sulfide
240	Sulfur Dioxide
245	Sulfur Trioxide
	Miscellaneous Inorganic Gases
250	Ammonia
260	Carbon Monoxide
270	Ozone
280	Radioactive Gases
290	Other Inorganic Gases
	ORGANIC GASES (Aromatic)
	Aromatic Hydrocarbons
305	Benzene
310	Toluene
315	Xylene
320	Naphthalene
325	BaP
326	Phenanthrene
327	Acridine
328	Chrysene
329	Pyrene
330	Anthracene
335	Naphthenes (Cyclohexane)
339	Coal Tar Pitch Volatiles (Benzene Soluable Fraction)
	Aromatic Phenols
340	All Phenol Compounds
	Aromatic Alcohols & Ethers
350	All Aromatic Alcohols
360	All Aromatic Ethers
	Aromatic Aldehydes & Ketones
370	Cyclohexanone
380	Other Aromatic Ketones
390	All Aromatic Aldehydes
	Aromatic Acids and Esters
400	All Aromatic Acids
410	All Aromatic Esters
	Aromatic Halogen Compounds
420	All Aromatic Halogens
	Aromatic Nitrogen Compounds
430	Aromatic Amines
435	Aromatic N Compounds
	Aromatic Sulfur Compounds
440	All Aromatic Sulfur Compounds
	Miscellaneous
490	All Other Aromatic Gases
	ORGANIC GASES (Aliphatic)
	Aliphatic Hydrocarbons
510	Methane
520	Other Non-Methane Alkanes
525	Acetylene
530	Butene
535	Ethylene
540	Propylene
545	Other Alkenes
550	Other Aliphatic Hydrocarbons
	Aliphatic Alcohols & Ethers
560	Methyl Alcohol (Methanol)
565	Ethyl Alcohol (Ethanol)
570	Isopropyl Alcohol
575	Isobutyl Alcohol
580	Other Aliphatic Alcohol
585	Dimethyl Ether
590	Ethyl Ether
595	Other Aliphatic Ethers
	Aliphatic Aldehydes & Ketones
600	Formaldehyde
605	Acetaldehyde
610	Acrolein
615	Other Aliphatic Aldehydes
620	Dimethyl Ketone (Acetone)
625	Diethyl Ketone
630	Methyl Ethyl Ketone (MEK)
635	Methyl Butyl Ketene (Hexanone)
640	Methyl Isobutyl Ketone (Hexone, MIBK)
645	Other Aliphatic Ketones
	Aliphatic Acids and Esters
650	Formic Acid
655	Acetic Acid
660	Other Aliphatic Acids
665	Methyl Formate
670	Ethyl Formate
675	Other Formates
680	Isopropyl Acetate
685	Other Acetates
690	Other Aliphatic Esters
	Aliphatic Halogen Compounds
700	Methyl Chloride
705	Chloroform
710	Carbon Tetrachloride
715	Perchloroethylene
720	Trichloroethane
725	Trichloroethylene
730	Phosgene
735	Vinyl Chloride
740	Other Aliphatic Chloride Compounds
750	Methyl Bromide
755	Vinyl Bromide
760	Other Aliphatic Bromides
770	Methyl Iodide
775	Other Aliphatic Iodines
780	Other Aliphatic Halogens
	Aliphatic Nitrogen Compounds
800	Hydrogen Cyanide
805	Cyanide Compounds NEC
810	Aniline
815	Hydrozine
820	Methyl Amine
830	Other Aliphatic Amines
	Aliphatic Sulfur Compounds
840	Methyl Mercaptan
845	Ethyl Mercaptan
850	Butyl Mercaptan
855	Other Aliphatic Mercaptans
860	Dimethyl Sulfide
865	Dimethyl Disulfide
870	Diethyl Sulfide
875	Other Aliphatic Sulfide
890	Other Aliphatic Sulfur Compounds
	Miscellaneous Organic Compounds
900	Gasoline
910	Kerosene
920	Paint Thinner
930	Organic Solvents
940	Sulfonic Acid
950	Non-Specific Odorous Organics
960	Radioactive Organics
990	Miscellaneous Organics

SOURCE: New York Department of Environmental Conservation.

TABLE 2.4

ALIPHATIC HALOGEN COMPOUNDS	ESTIMATED AMOUNT
Chloroform:	120,000 pounds per year emitted in Monroe County - no appreciable emissions indicated for other counties bordering the lake.
Carbon tetrachloride:	5,600 pounds per year, Monroe County.
Perchloroethylene:	20,000 to 50,000 pounds per year in almost every county.
Trichloroethane:	130,000 pounds per year in Chautaugua County - others comparable.
Trichloroethylene:	20 to 50,000 pounds per year in almost every county.
Phosgene:	1,000 pounds per year indicated for Niagara County - none from other counties bordering the lake.
Vinyl chloride:	200 pounds per year from Monroe County; 290,000 from Niagara County; and none from others on the lake.
Other aliphatic chloride compounds:	4,000,000 pounds per year in Monroe County, and lesser, but large (100,000 lbs/year) amounts elsewhere show this to be truly a "catch-all" category.

SOURCE: New York Department of Environmental Conservation

TABLE 2.5

AIR EMISSION INVENTORY FOR NEW YORK COUNTIES IN LAKE ONTARIO DRAINAGE BASIN IN 1976

CONTAMINANTS	NO. OF SOURCES	ACTUAL (tons/year)
Sulfuric Acid Mist	215	273
Hydrogen Chloride	331	1,364
Hydrogen Fluoride	104	229
Benzene	24	375
Toluene	723	3,732
Xylene	540	2,383
Naphthalene	43	1,051
Coal Tar Pitch	0	0
All Pehnol Compounds	96	62
Formaldehyde	178	226
Dimethyl Ketone	214	1,997
Methyl Ethyl Ketone	260	800
Methyl Chloride	13	5
Arsenic	41	0
Cadmium	5	1
Copper	46	52
Iron	541	1,752
Lead	81	5
Manganese	12	35
Mercury	16	1
Selenium	43	1
Zinc	169	205
Nitric Acid Mist	158	58

SOURCE: New York Department of Environmental Conservation

3. DATA ON SEWAGE SLUDGE

Sewage sludge from industrial and municipal wastewater treatment plants is frequently contaminated with PCB. The problem of soil and crop contamination from disposal of this material was investigated by Agriculture Canada in 1972 and 1973. Sewage sludge samples were collected from Southern Ontario and analyzed for PCBs. Much of the sludge went to farmland as manure whilst the rest went to landfill. Samples of soil from some of the treated farmland were analyzed as were some of the crops. Table 3.1 shows the levels of PCB in the sludges, Table 3.2 levels of PCB in soils treated with sludge and Table 3.3 levels of PCB in crops from treated fields.

The ultimate fate of PCB disposed of in this way is uncertain. Presumably there will be some adsorption into soil particles and some will be leached into drainage water. Degradation by the soil microflora probably occurs in the soil. Volatilization, transportation, reprecipitation and photodegradation are other factors affecting the concentration of PCBs in the treated soils. A quantitative assessment of these phenomena in the field has not been attempted.

TABLE 3.1

CONCENTRATION OF PCB IN ONTARIO SEWAGE SLUDGE IN ppm DRY MATTER, 1972 AND 1973

LAKE ONTARIO WATERSHED	PCB (ppm)	TYPE
Georgetown	5.37	1254
Richmond Hill	1.86	1254
Peterborough	6.79	1254
Welland	4.52	1254
Toronto (Humber)	49.45	1254
Stanford Niagara	1.76	1254
Port Weller	10.0	1254
Port Dalhousie	10.3	1254
Burlington (Drury)	9.2	1254
Burlington (Skyway)	21.0	1260
Hamilton	32.5	1254
Oakville (S.E.)	4.6	1254
Oakville (S.W.)	31.4	1254
Lakeview	12.2	1254
Clarkson	31.7	1260
North Toronto	1.55	1254
Whitby	11.6	1254
Ajax	1.76	1254
Pickering	2.92	1254
Bowmanville	11.1	1254
Oshawa	2.50	1254

SOURCE: Polychlorinated Biphenyls in the Ontario Environment, MOE report, July 1976.

TABLE 3.2

CONCENTRATION OF PCB IN ppb IN SOILS TREATED WITH SEWAGE SLUDGE FROM SOUTHERN ONTARIO. 1972

LOCATION	SOURCE OF SLUDGE	NUMBER OF APPLICATION	PCB	TYPE
Norval	Georgetown	1	10	1254
Norval	Georgetown	1	7	1254
Georgetown	Georgetown	1	37	1254
Stratford	Stratford	Several	715	1254
Whitby	Whitby	1	N.D.	-
Ajax	Ajax	1	43	1260
Pickering	Pickering	6	150	1254
Bowmanville	Bowmanville	1	46	1254
Oshawa	Oshawa	1	N.D.	-
Vineland	Port Dalhousie	1	N.D.	-
Toronto Int. Airport	Stratford	1	120	1254
Halton City	Burlington	2	150	1260
Richmond Hill	Richmond Hill	several x/yr/5 yr	N.D.	-
Aurora	Aurora	2-3	8	1254

SOURCE: Polychlorinated Biphenyls in the Ontario Environment, MOE Report, July 1976.

TABLE 3.3

CONCENTRATION OF PCB IN CROPS FROM FIELDS TREATED WITH SEWAGE SLUDGE IN ppb

LOCATION	SOURCE	CROP	PCB	TYPE
Norval	Georgetown	Corn	N.D.	-
Norval	untreated	Corn	N.D.	-
Norval	Georgetown	Tomatoes	N.D.	-
Norval	unknown	Corn	N.D.	-
Norval	Georgetown	Mixed grain	28	1254
Georgetown	Georgetown	Apples	N.D.	-

N.D. - None detected.

(From CDA unpublished survey)

SOURCE: Polychlorinated Biphenyls in the Ontario Environment, MOE Report, July 1976.

4. RUNOFFS

The leachate from seven landfill sites in Ontario was sampled in July, 1975 and analyzed by the Ministry of the Environment, Ontario. The results are shown in Table 4.1. The small amount of PCB in groundwater from a landfill site indicates that landfill leachate is probably not a major source of PCB into the Great Lakes environment. However these data are not extensive and are only concerned with concentrations rather than quantities.

TABLE 4.1

CONCENTRATION OF PCB IN LEACHATE FROM SEVERAL ONTARIO LANDFILL SITES. 1975

Location	PCB in ppb
Violet	Not detected
Beare Road	0.04
Preston	0.02
Mississauga	1.2
Brantford	0.24

Source: PCB in the Ontario Environment, MOE Report, July 1976.

5. SEDIMENTS

The results of six sediment samples for organochlorine pesticides and polychlorinated biphenyls collected by Environment Canada in the Cobourg Harbour are shown in Table 5.1.

Data collected as part of the International Field Year for the Great Lakes (IFYGL) included levels of chlorinated hydrocarbons in Lake Ontario sediments. Table 5.2 shows concentrations of t-DDT, dieldrin, and PCBs. Average sediment t-DDT, dieldrin, and PCB concentrations were 22, 1.2 and 120 ng/g, respectively. Sediment off the mouth of the Welland Canal showed higher levels of all three contaminants while sediments off the mouth of the Niagara River contained higher levels of PCBs and dieldrin. Sediments off Oswego and at an eastern mid-lake site showed higher levels of PCBs and dieldrin, respectively. High concentrations of PCBs in waters and sediments off the mouth of the Niagara River and Oswego indicate the importance of the Niagara and Oswego Rivers as inputs of PCBs associated with settleable particulates. In most cases, t-DDT concentrations were similar to concentrations of the DDT metabolite, DDE, except in sediments where DDT and DDD contributed much larger fractions. Table 5.3 shows levels of arsenic and selenium in sediments from Lake Ontario. Data for Σ DDT, PCBs, mirex, chlordane, dieldrin, endosulfan, polycyclic aromatic hydrocarbons and metals are contained in Tables 5.4 to 5.9.

Levels of PCB in sediments show distribution patterns corresponding to density of municipal and industrial development. A 1972 survey of PCB in sediments in Hamilton Harbour by the Ministry of the Environment showed levels of 1,300 ppb in the canal region, 2000 to 3000 ppb in the region of the industrial waterfront and 10,000 ppb near the sewage treatment plant. The Ontario Ministry of the Environment is presently analyzing for copper, lead, zinc, and PCBs in Toronto Harbour sediments. The following substances are being monitored in the Twelve Mile Creek: copper, zinc, cadmium, lead, chromium, mercury, PCB and DDT. Data will be available February 1977.

Sediment samples were collected at 11 sampling locations on Lakes Ontario, Erie and St. Clair during the fall of 1975 and analyzed for chlorinated hydrocarbon residues. Of all sediment samples analyzed, 50% contained PCB and 90% DDT residues. Mean PCB residues in the sandy sediments ranged from non-detectable to 57 ng/g (ppb) levels, whereas residues in the more organic sediments ranged from non-detectable to 569 ng/g. Mean total DDT residues ranged from 2 ng/g - 15 ng/g in the sandy sediments and 7 ng/g -88 ng/g in the more organic sediments. Detailed data are shown in Table 5.10.

Bulk sediment analyses and elutriate tests were carried out by U.S. EPA Region V in Oswego Harbor, New York on April 22, 1976. Results on mercury, lead, zinc, nickel, arsenic, cadmium, chromium, copper and iron are shown in Tables 5.11 and 5.12 respectively. Figure 5.1 shows the sampling locations.

A similar study of sediments in Rochester Harbor was also carried out. Results of bulk sediment analyses and elutriate tests are shown in Tables 5.13 and 5.14 respectively. Figure 5.2 shows the sampling locations.

TABLE 5.1

ANALYSIS OF SEDIMENT

(In Micrograms per gram)

REFERENCE	Cobourg 1	Cobourg 2	Cobourg 3	Cobourg 4	Cobourg 5	Cobourg 6
LABORATORY NUMBER	13733	13734	13735	13736	13737	13738
LINDANE	N.D.	N.D.	N.D.	N.D.	N.D	N.D.
HEPTACHLOR	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
ALDRIN	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
HEPTACHLOR EPOXIDE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
p,p'-DDE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
DIELDRIN	N.D	0.001	0.001	0.001	0.001	0.002
p,p'-DDD	0.001	0.001	0.002	N.D.	0.002	0.002
p,p'-DDT	N.D.	N.D.	N.D.	N.D.	0.001	0.001
p,p'-DDT	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
ENDRIN	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
CIS-CHLORDANE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
TRAN-CHLORDANE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
α ENDOSULFAN	N.D	N.D.	N.D.	N.D.	N.D	0.001
β ENDOSULFAN	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
p,p'-METHOXYCHLOR	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
TOTAL PCB	0.3	0.5	0.1	0.2	0.2	0.1

SOURCE: Canada Centre for Inland Waters

TABLE 5.2

CHLORINATED HYDROCARBONS IN LAKE ONTARIO SEDIMENT
(ng/g dry sediment)[a]

LOCATION	IFYGL STATION IDENTIFIER	DDE	DDD	DDT	TOTAL DDT	DIELDRIN	PCB
Welland Canal	12	12	15	12	39	2.6	245
Niagara River	13	11	3.5	0.7	15	1.4	155
Olcott	30	4.8	5.6	1.2	12	0.9	80
Cobourg	36	8.0	0.9	0.9	10	0.6	43
Mid-lake	46	11	5.4	2.8	19	0.5	79
Rochester	60	8.0	1.5	0.2	10	0.9	84
Oswego	91	9.0	5.1	3.8	18	0.8	158
Mid-lake East	93	16	31	7.4	54	2.1	N.D.

[a]N.D. indicates no determination was made.

SOURCE: EPA-660/3-75-022 "Chlorinated Hydrocarbons in the Lake Ontario Ecosystem (IFYGL)", June 1975.

TABLE 5.3

LEVELS OF ARSENIC AND SELENIUM IN SEDIMENTS FROM LAKE ONTARIO

BASIN	STATION	LATITUDE	LONGITUDE	ARSENIC μg/g (dry)	SELENIUM μg/g (dry)
Niagara	B-3	43°17.2'	79°36.00'	2.0	0.8
	B-7	43°17.3'	79°12.10'	3.5	0.8
	D-5	43°25.7'	79°24.30'	2.5	1.1
Mississauga	D-16	43°25.8'	78°17.80'	4.0	1.8
	E-14	43°30.2'	78°30.00'	2.0	0.5
	F-20	43°34.4'	77°54.00'	3.0	1.7
Rochester	E-27	43°30.0'	77°12.10'	1.5	1.0
Kingston	L-35	44°00.5'	76°24.00'	14.0	0.3

SOURCE: IWD Environment Canada "Level of Arsenic and Selenium in the Great Lakes Region", Scientific Series No. 58, 1975.

TABLE 5.4

ABUNDANCES OF POLYCYCLIC AROMATICS IN LAKE ONTARIO SEDIMENT,* STATION NO. 1**

AROMATIC	0-5 cm	10-15 cm	20-25 cm	30-35 cm	55-60 cm	70-75 cm
Biphenyl	0.017	0.040	0.024	0.005	0.004	0.004
Anthracene	0.026	0.012	–	–	–	–
Penanthrene	0.040	0.030	–	–	–	–
2-Methyl Anthracene	–	0.025	–	–	–	–
9-Methyl Anthracene	–	0.039	–	–	–	–
Tetrahydropyrene	0.200	0.064	–	–	–	–
Fluoranthene	1.000	0.255	–	–	–	–
9,10-Dimethyl Anthracene	0.067	0.032	–	–	–	–
Pyrene	1.133	0.350	–	–	–	–
Benzofluorenes	0.133	0.064	–	–	–	–
1,2-Benzanthracene, Chrysene, Triphenylene	1.067	0.637	0.024	0.039	0.056	–
Methyl Chrysene	0.467	0.096	–	–	–	–
Dimethyl Chrysene	0.400	0.096	–	–	–	–
2,3-Benzofluoranthene	0.533	0.127	–	–	–	–
Methyl Benzofluoranthene	0.333	0.064	–	–	–	–
Benzpyrenes	0.533	0.191	–	–	–	–
Perylene	0.200	0.255	0.453	0.392	0.111	0.090
Methyl Benzpyrene	0.200	0.127	–	–	–	–
Methyl Perylene	0.067	0.064	–	–	–	–
20-Methyl Cholanthrene	1.067	0.127	–	–	–	–
Benzperylene	0.267	0.191	0.098	0.039	–	–
Coronene	1.333	0.956	0.488	0.196	–	–
Total Aromatics	9.083	3.840	1.087	0.671	0.171	0.094

*Concentrations in µg/g of dry sediment.
** (Lat. 43° 19' 12", Long. 79° 42' 00")

TABLE 5.5

ABUNDANCES OF POLYCYCLIC AROMATICS IN LAKE ONTARIO

SEDIMENT,* STATION NO. 12**

AROMATIC	0-5 cm	10-15 cm	20-25 cm	30-35 cm	55-60 cm	70-75 cm
Biphenyl	0.023	0.015	0.019	0.043	0.009	0.008
Anthracene	0.105	0.038	0.020	-	-	-
Penanthrene	0.077	0.023	0.008	-	-	-
2-Methyl Anthracene	0.105	-	-	-	-	-
9-Methyl Anthracene	0.168	-	-	-	-	-
Tetrahydropyrene	0.273	0.061	0.038	0.035	-	-
Fluoranthene	0.909	0.123	0.038	0.035	-	-
Pyrene	1.182	0.061	0.075	0.035	-	-
Benzofluorenes	0.273	0.061	0.038	0.069	-	-
1,2-Benzanthracene, Chrysene, Triphenylene	1.455	0.184	0.075	0.104	0.179	0.065
Dimethyl Chrysene	0.273	0.245	0.038	0.035	0.036	0.098
2,3-Benzofluoranthene	1.273	0.061	0.075	0.035	0.143	0.065
Methyl Benzofluoranthene	0.182	-	-	-	-	-
Benzpyrenes	0.818	0.061	0.075	0.104	0.536	0.033
Perylene	0.909	0.552	0.262	0.415	0.893	0.554
Methyl Benzpyrene	0.273	0.184	0.112	-	-	-
Methyl Perylene	0.364	0.061	-	-	-	-
20-Methyl Cholanthrene	0.727	0.123	0.375	0.138	0.208	-
Benzperylene	1.818	0.123	0.225	0.069	-	-
Coronene	2.727	0.614	0.375	-	-	-
Total Aromatics	13.94	2.590	1.848	1.117	2.004	0.823

*Concentrations in µg/g of dry sediment.
**(Lat. 43° 25' 54", Long. 79° 24' 00")

SOURCE: Canada Centre for Inland Waters, 1973

TABLE 5.6

ABUNDANCES OF POLYCYCLIC AROMATICS IN LAKE ONTARIO SEDIMENT,* STATION NO. 48**

AROMATIC	0-5 cm	10-15 cm	20-25 cm	30-35 cm	55-60 cm	70-75 cm
Biphenyl	0.014	0.007	0.009	0.004	0.004	0.004
Tetrahydropyrene	0.056	0.029	-	-	-	-
Fluoranthene	0.281	0.058	-	-	-	-
Pyrene	0.056	0.029	-	-	-	-
1,2-Benzanthracene Chrysene Triphenylene	0.225	0.088	0.052	-	-	-
Dimethyl Chrysene	0.112	-	-	-	-	0.018
2,3-Benzofluoranthene	0.450	0.029	0.017	0.017	0.020	0.009
Methyl Benzofluoranthene	0.056	-	-	-	-	-
Benzpyrenes	0.337	-	0.017	0.034	0.010	0.009
Perylene	0.056	0.029	0.017	0.034	0.30	0.046
Methyl Benzpyrene	0.056	-	-	-	-	-
Methyl Perylene	0.112	-	-	-	0.010	0.027
20-Methyl Cholanthrene	0.337	-	-	-	-	0.018
Benzperylene	0.225	-	-	-	-	-
Coronene	0.562	-	-	-	-	-
Total Aromatics	2.935	0.269	0.112	0.089	0.084	0.131

*Concentrations in µg/g of dry sediment.
**(Lat. 43° 39', Long. 78° 12')

SOURCE: Canada Centre for Inland Waters, 1973

TABLE 5.7

ABUNDANCES OF POLYCYCLIC AROMATICS IN LAKE ONTARIO SEDIMENT,* STATION NO. 76**

AROMATIC	0-5 cm	10-15 cm	20-25 cm	30-35 cm	55-60 cm	70-75 cm
Biphenyl	–	–	–	–	0.018	0.004
Chrysene	–	0.350	–	–	–	–
Dimethyl Chrysene	0.484	0.300	0.122	0.124	–	–
2,3-Benzofluoranthene	1.774	0.100	0.081	0.062	–	–
Benzpyrenes	0.161	0.050	0.041	0.062	–	–
Perylene	0.161	0.150	0.122	0.683	0.141	0.177
Methyl Perylene	–	0.150	–	–	–	–
20-Methyl Cholanthrene	–	0.150	–	–	–	–
Total Aromatics	2.580	1.250	0.366	0.931	0.159	0.181

*Concentrations in μg/g of dry sediment.
**(Lat. 43° 30' 18", Long. 77°)

SOURCE: Canada Centre for Inland Waters, 1973

TABLE 5.8

ABUNDANCES OF POLYCYCLIC AROMATICS IN LAKE ONTARIO SEDIMENT,* STATION NO. 93**

AROMATIC	0-5 cm	10-15 cm	20-25 cm	30-35 cm	55-60 cm	70-75 cm
Biphenyl	-	-	0.008	0.004	-	-
Tetrahydropyrene	0.108	-	-	-	-	-
Fluoranthene	0.270	0.030	0.033	0.013	-	-
9,10-Dimethyl Anthracene	0.054	-	-	-	-	-
Pyrene	0.216	0.030	0.033	0.013	-	-
1,2-Benzanthracene						
Chrysene	0.324	0.089	0.033	0.013	0.023	0.040
Triphenylene						
Dimethyl Chrysene	0.054	0.030	0.033	0.025	-	-
2,3-Benzofluoranthene	0.108	0.030	0.033	0.050	0.081	0.069
Benzpyrenes	0.108	0.030	0.033	0.038	0.046	0.040
Perylene	0.433	0.799	0.492	0.375	0.322	0.485
20-Methyl Cholanthrene	0.649	-	0.066	0.050	0.046	-
Benzperylene	0.108	0.059	0.033	-	-	-
Total Aromatics	2.432	1.087	0.797	0.581	0.518	0.634

*Concentrations in μg/g of dry sediment.
**(Lat. 44° 00' 42", Long. 76° 30')

SOURCE: Canada Centre for Inland Waters, 1973

TABLE 5.9							
LAKE ONTARIO SEDIMENTS IN 1968 (Units in µg/ℓ unless otherwise specified)							
	Samples Analysed No.	Not det. in No.	Found in %	Min. Value	Max. Value	Mean Value	S.D. PPB
Σ DDT	229	0	100%	.4	217.7	42.8	42.5
PCB	229	20	91.3	1	280	59.4	56.1
Mirex	216	154	28.7	1	40	7.5	8.3
Chlordane	54	49	9.3	5	40	13.2	15.1
Dieldrin	229	162	9.3	.5	5.2	1.8	1.2
Endosulfan	229	208	9.2	1.2	9.4	3.2	2.3
Arsenic	115	0	100	0.2 mg/ℓ	22.5 mg/ℓ	3.3 mg/ℓ	
Cadmium				0.1 mg/ℓ	20.6 mg/ℓ	25 mg/ℓ	
Lead				4 mg/ℓ	287 mg/ℓ	106 mg/ℓ	
Mercury				25	2100	651	
Copper				3 mg/ℓ	131 mg/ℓ	50 mg/ℓ	
Nickel				4 mg/ℓ	121 mg/ℓ	52 mg/ℓ	
Iron				0.7	9.6		
Chromium				0.1 mg/ℓ	133 mg/ℓ	48 mg/ℓ	

SOURCE: Canada Centre for Inland Waters

TABLE 5.10

MEAN CONCENTRATIONS OF CHLORINATED HYDROCARBONS IN LAKE SEDIMENTS FROM LAKES ONTARIO, ERIE AND ST. CLAIR - 1975 (NG/G DRY SEDIMENT)

LOCATION	NUMBER OF ANALYSES	PCB	ΣDDT	DIELDRIN	CHLORDANE	CHLORDANE	THIODAN I	THIODAN II
GLENORA								
Sand	4	ND	6	ND	ND	ND	ND	ND
Other	2	490	18	ND	1	ND	ND	ND
PRESQUILE								
Sand	6	ND	3	ND	ND	ND	ND	ND
Other								
DARLINGTON								
Sand	8	12	2	ND	1	1	ND	ND
Other	4	178	10	ND	4	4	ND	ND
FRENCHMANS BAY								
Sand	2	ND	6	3	1	1	ND	ND
Other	10	ND	27	5	2	1	ND	ND
TORONTO HARBOUR								
Sand	5	50	6	ND	1	2	ND	ND
Other	7	569	36	ND	6	7	ND	ND
PORT CREDIT								
Sand	9	7	3	ND	1	2	ND	ND
Other	3	247	52	ND	1	2	ND	ND
NIAGARA ON THE LAKE								
Sand	10	42	5	1	2	2	Trace	9
Other	2	70	88	6	40	6	ND	ND
PORT COLBORNE								
Sand	4	25	3	ND	1	1	ND	ND
Other	8	32	7	ND	2	2	ND	ND
PORT ROWAN								
Sand	1	40	15	ND	ND	ND	ND	ND
Other	5	ND	22	ND	4	3	ND	ND
POINT PELEE								
Sand	7	57	15	ND	3	3	ND	ND
Other	5	79	29	ND	6	7	ND	ND
TREMBLAY CREEK								
Sand	11	ND	2	ND	Trace	Trace	ND	ND
Other	1	ND	10	ND	ND	ND	ND	ND

TABLE 5.11

BULK SEDIMENT ANALYSIS RESULTS

HARBOR: Oswego, New York

SAMPLED: April 22, 1976

PARAMETER	OSW76-3	OSW76-4	OSW76-5	OSW76-6	OSW76-7	OSW76-8	OSW76-9	OSW76-10	OSW76-10 split	OSW76-10 replicate	OSW76-10 replicate split	OSW76-11
Total Solids %	56.5	60.4	43.6	49.3	46.8	62.3	57.8	49.0	51.5	55.8	52.5	70.1
Volatile Solids %	3.38	2.36	5.02	4.98	6.10	2.92	4.47	4.76	4.58	3.78	4.20	2.48
Chem. Oxygen Demand	37,000	27,000	72,000	69,000	87,000	48,000	40,000	52,000	47,000	41,000	37,000	18,000
T. Kjel. Nitrogen	1,200	520	2,200	1,900	2,300	680	800	850	670	640	540	590
Oil-Grease	700	400	1,500	1,000	1,000	900	800	1,100	1,400	1,300	1,200	---
Mercury	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
Lead	29	25	47	37	37	17	27	57	59	55	50	148
Zinc	110	60	190	140	120	78	120	120	120	130	120	130
T. Phosphorus	590	560	1,000	840	900	590	660	1,800	1,600	1,400	1,200	590
Ammonia Nitrogen	58	71	160	110	120	87	92	87	74	67	70	49
Manganese	330	360	580	550	520	380	350	400	400	350	360	300
Nickel	17	9.2	23	20	24	16	20	20	21	17	18	14
Arsenic	7	8	11	9	11	8	10	9	9	7	7	7
Cadmium	1.7	<1	3.4	1.2	2.2	<1	1.2	2.6	2.5	1.8	1.8	<1
Chromium	16	10	30	22	23	14	17	21	22	24	23	13
Magnesium	4,900	4,400	6,600	6,800	6,800	5,600	5,700	6,400	5,900	5,500	5,600	3,400
Copper	25	17	42	36	44	26	40	37	37	34	34	54
Iron	8,100	7,200	11,000	11,000	12,000	10,000	10,000	9,400	9,600	9,200	9,400	8,200

All values mg/kg dry weight unless otherwise noted.

TABLE 5.12

ELUTRIATE TEST RESULTS

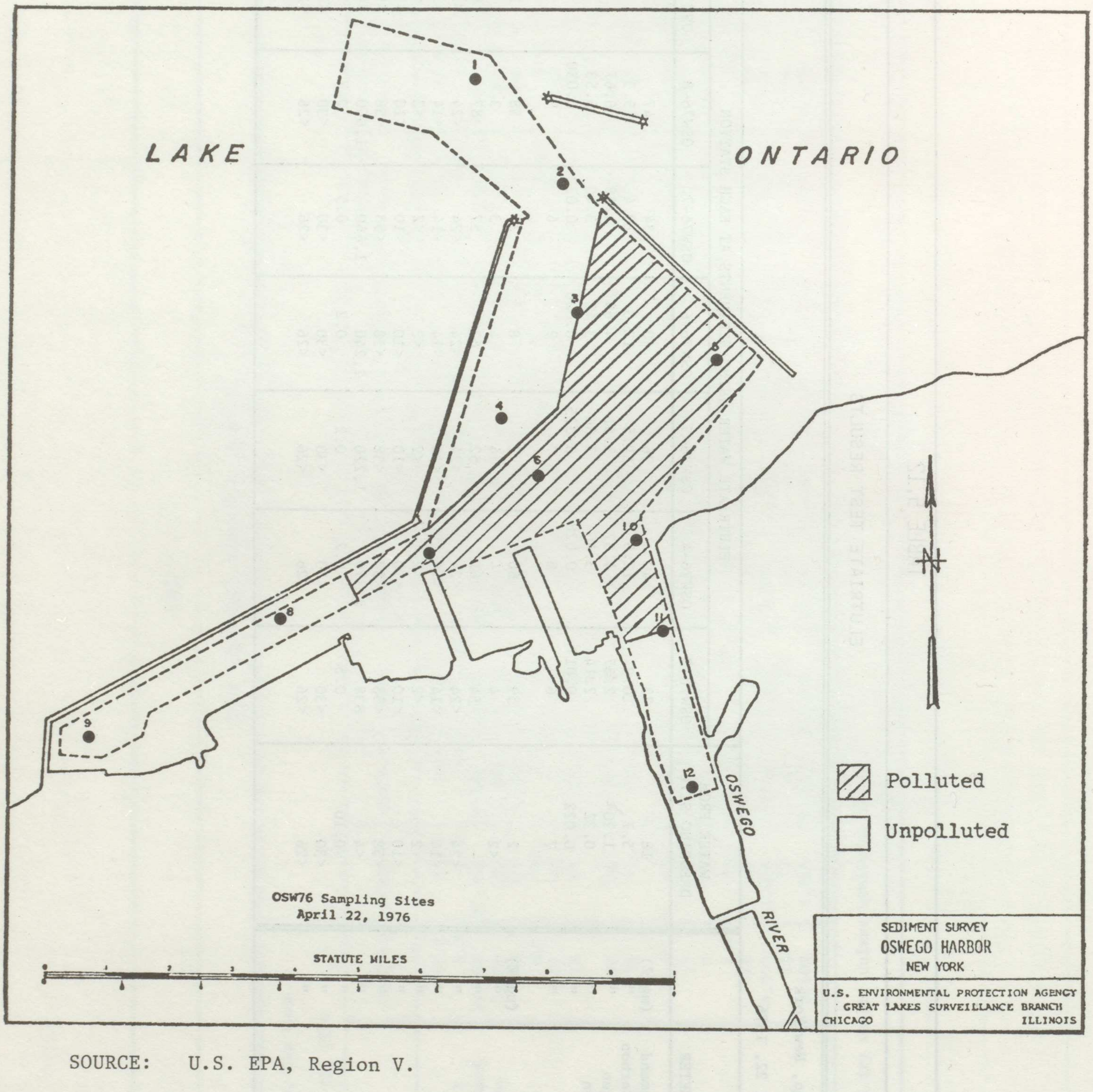
HARBOR: Oswego, New York

SAMPLED: April 22, 1976

EVALUATED PARAMETER		WATER FROM DREDGING SITE	ELUTRIATE WATER USING SEDIMENTS AT EACH STATION							
			OSW76-3	OSW76-4	OSW76-5	OSW76-6	OSW76-7	OSW76-8	OSW76-9	OSW76-10
Chem. Oxygen Demand	(mg/ℓ)	18	33	40	36	40	34	47	15	20
Total Organic Carbon	"	5.7	10.3	12.5	11.5	12.0	10.4	15.3	6.1	6.0
T. Kjel. Nitrogen	"	1.20	2.87	4.37	5.51	4.69	4.68	6.67	6.68	3.17
Ammonia Nitrogen	"	0.32	2.14	3.40	3.66	3.42	3.40	5.53	6.02	2.02
T. Phosphorus	"	0.022	0.017	0.028	0.025	0.020	0.022	0.030	0.018	0.030
Cyanide	"	7	6	8	7	9	6	9	7	8
Phenols	(μg/ℓ)	2	59	66	2	8	25	58	20	42
Arsenic	"	<2	4	4	4	4	3	3	4	6
Barium	"	-	54	61	52	63	57	87	69	46
Cadmium	"	<24	<24	<24	<24	<24	<24	<24	<24	<24
Chromium	"	<14	<14	<14	<14	<14	<14	<14	<14	<14
Copper	"	<2	<2	<2	<2	<2	<2	<2	<2	<2
Iron	"	<10	<10	<10	<10	<10	<10	<10	<10	75
Lead	"	<58	<58	<58	<58	<58	<58	<58	<58	<58
Manganese	"	<4	838	2,370	1,220	2,240	1,660	1,660	704	727
Mercury	"	<0.10	0.5	0.2	0.2	0.2	0.5	0.2	0.1	0.1
Zinc	"	<30	<30	<30	<30	<30	<30	<30	<30	<30
Aluminum	"	<26	<26	<26	<26	<26	<26	<26	<26	<26

FIGURE 5.1

SAMPLE LOCATIONS AND POLLUTIONAL CLASSIFICATION OF THE OSWEGO HARBOR



SOURCE: U.S. EPA, Region V.

TABLE 5.13

BULK SEDIMENT ANALYSIS RESULTS

HARBOR: Rochester, New York

SAMPLED: April 20, 1976

PARAMETER	ROCH76-1	ROCH76-2	ROCH76-3	ROCH76-4	ROCH76-4 split	ROCH76-4 replicate	ROCH76-4 replicate split	ROCH76-5	ROCH76-6	ROCH76-7	ROCH76-8	ROCH76-9	ROCH76-10	ROCH76-A
Total Solids %	67.6	62.4	57.6	59.2	57.9	57.8	61.8	57.2	59.4	56.0	60.9	60.7	65.7	59.2
Volatile Solids %	<1.00	3.33	3.54	3.62	3.54	3.13	3.08	3.58	3.17	3.24	2.98	4.50	2.27	3.21
Chem. Oxy. Demand	26,000	31,000	37,000	37,000	41,000	32,000	30,000	38,000	38,000	33,000	29,000	21,000	12,000	32,000
T. Kjel. Nitrogen	<100	800	980	1,100	1,100	1,000	700	1,200	850	1,100	630	280	390	800
Oil-Grease	900	600	800	1,000	900	900	900	500	700	900	500	1,000	300	600
Mercury	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Lead	9	33	33	29	29	24	27	39	35	33	36	33	31	35
Zinc	64	200	160	120	130	110	120	170	150	130	130	110	82	140
T. Phosphorus	340	640	710	660	670	660	600	770	660	620	580	380	350	670
Ammonia Nitrogen	24	100	98	71	68	61	72	98	95	95	110	49	40	60
Manganese	210	400	410	460	460	440	440	460	380	390	400	440	290	340
Nickel	10	22	23	22	23	22	23	23	19	21	20	22	15	24
Arsenic	3	6	8	9	12	11	10	4	15	16	9	10	7	10
Cadmium	<1	6.3	1	3.3	2.9	3.1	3.5	6.8	4.5	5.8	4.5	<1	3.0	1.8
Chromium	6	25	20	19	19	17	18	28	21	24	23	19	14	14
Magnesium	2,250	5,200	5,200	4,400	4,500	5,200	5,300	5,000	4,500	4,700	4,500	4,900	2,900	6,100
Copper	4.4	30	28	28	28	27	28	34	28	28	28	25	19	35
Iron	6,500	18,000	21,000	22,000	23,000	21,000	21,000	23,000	19,000	19,000	19,000	20,000	16,000	17,000

All values mg/kg dry weight unless otherwise noted.

TABLE 5.14

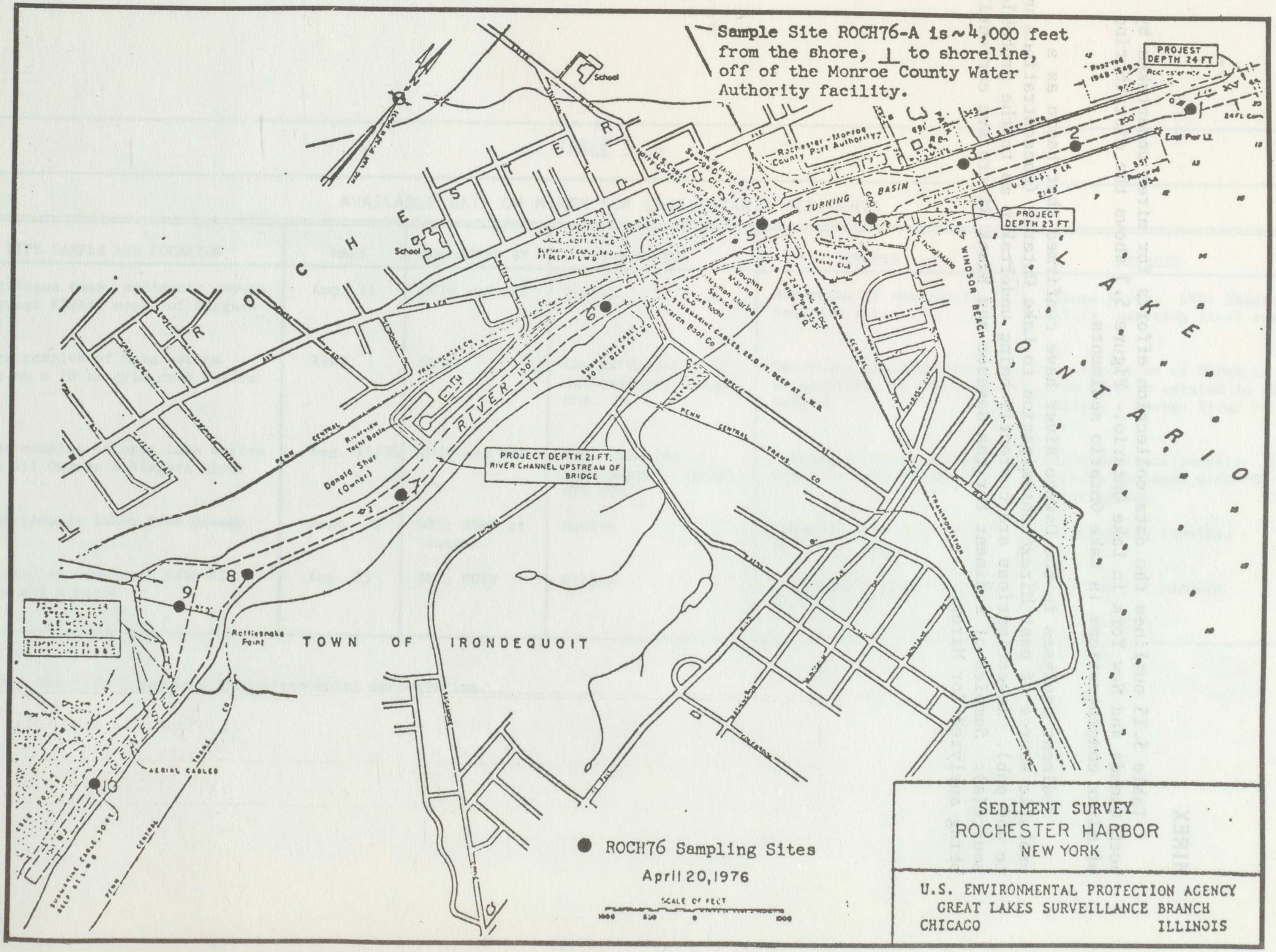
ELUTRIATE TEST RESULTS

HARBOR: Rochester, New York

SAMPLED: April 20, 1976

EVALUATED PARAMETER		WATER FROM DREDGING SITE	ELUTRIATE WATER USING SEDIMENTS AT EACH STATION									
			ROCH76-1	ROCH76-2	ROCH76-3	ROCH76-4	ROCH76-5	ROCH76-6	ROCH76-7	ROCH76-8	ROCH76-9	ROCH76-10
Chem. Oxy. Demand	(mg/ℓ)	11	13	13	15	20	12	10	12	13	49	20
Total Organic Carbon	"	3.5	3.4	4.8	5.8	6.5	5.3	4.7	5.0	5.2	18.2	7.4
T. Kjel. Nitrogen	"	0.79	0.96	5.20	3.83	2.97	3.69	3.55	5.47	6.66	3.48	2.58
Ammonia Nitrogen	"	0.24	0.47	<.03	2.77	1.80	2.43	2.62	4.49	5.56	2.20	1.50
T. Phosphorus	"	0.010	0.039	0.043	0.024	0.030	0.026	0.037	0.028	0.018	0.026	0.024
Cyanide	"	<5	8	9	10	22	11	12	10	8	24	21
Phenols	(µg/ℓ)	19	21	8	13	10	10	15	28	25	950	158
Arsenic	"		<5	5	26	9	13	13	15	13	17	13
Barium	"		37	61	73	84	65	69	76	82	119	77
Cadmium	"		<24	<24	<24	<24	<24	<24	<24	<24	<24	<24
Chromium	"		<14	<14	<14	<14	<14	<14	<14	<14	<14	<14
Copper	"		<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Iron	"		<10	<10	<10	<10	<10	<10	<10	<10	55	<10
Lead	"		<58	<58	<58	<58	<58	<58	<58	<58	<58	<58
Manganese	"		46	434	1,350	1,620	646	830	1,290	1,240	2,640	1,920
Mercury	"	0.5	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.3	<0.1	<0.1
Zinc	"		<30	<30	<30	<30	31	<30	<30	31	35	<30
Aluminum	"		<26	<26	<26	<26	<26	<26	<26	<26	<26	<26

FIGURE 5.2


Sample Site ROCH76-A is ~4,000 feet from the shore, ⊥ to shoreline, off of the Monroe County Water Authority facility.
PROJECT DEPTH 24 FT
PROJECT DEPTH 23 FT
PROJECT DEPTH 21 FT. RIVER CHANNEL UPSTREAM OF BRIDGE
LAKE ONTARIO
ROCHESTER
TURNING BASIN
RIVER
GENESEE
TOWN OF IRONDEQUOIT
Rattlesnake Point
Windsor Beach
School
Rochester-Monroe County Port Authority
East Pier Lt.
Donald Shur (Owner)
Riverview Yacht Basin
SUBMARINE CABLES
AERIAL CABLES
PENN CENTRAL
ROCH76 Sampling Sites
April 20, 1976
SCALE OF FEET
SEDIMENT SURVEY
ROCHESTER HARBOR
NEW YORK
U.S. ENVIRONMENTAL PROTECTION AGENCY
GREAT LAKES SURVEILLANCE BRANCH
CHICAGO ILLINOIS

MIREX

Table 5.15 outlines the data collection efforts for mirex undertaken by both Canada and New York in Lake Ontario. Figure 5.3 shows the distribution of mirex concentrations in Lake Ontario sediments.

Sediment analyses in the Oswego River have confirmed that basin as a probable source of past Mirex contamination to Lake Ontario (concentrations up to 440 ppb). Investigations are currently being undertaken as to the probable source(s). Samples of sediment for the Genesee and Black Rivers are currently being analyzed for Mirex.

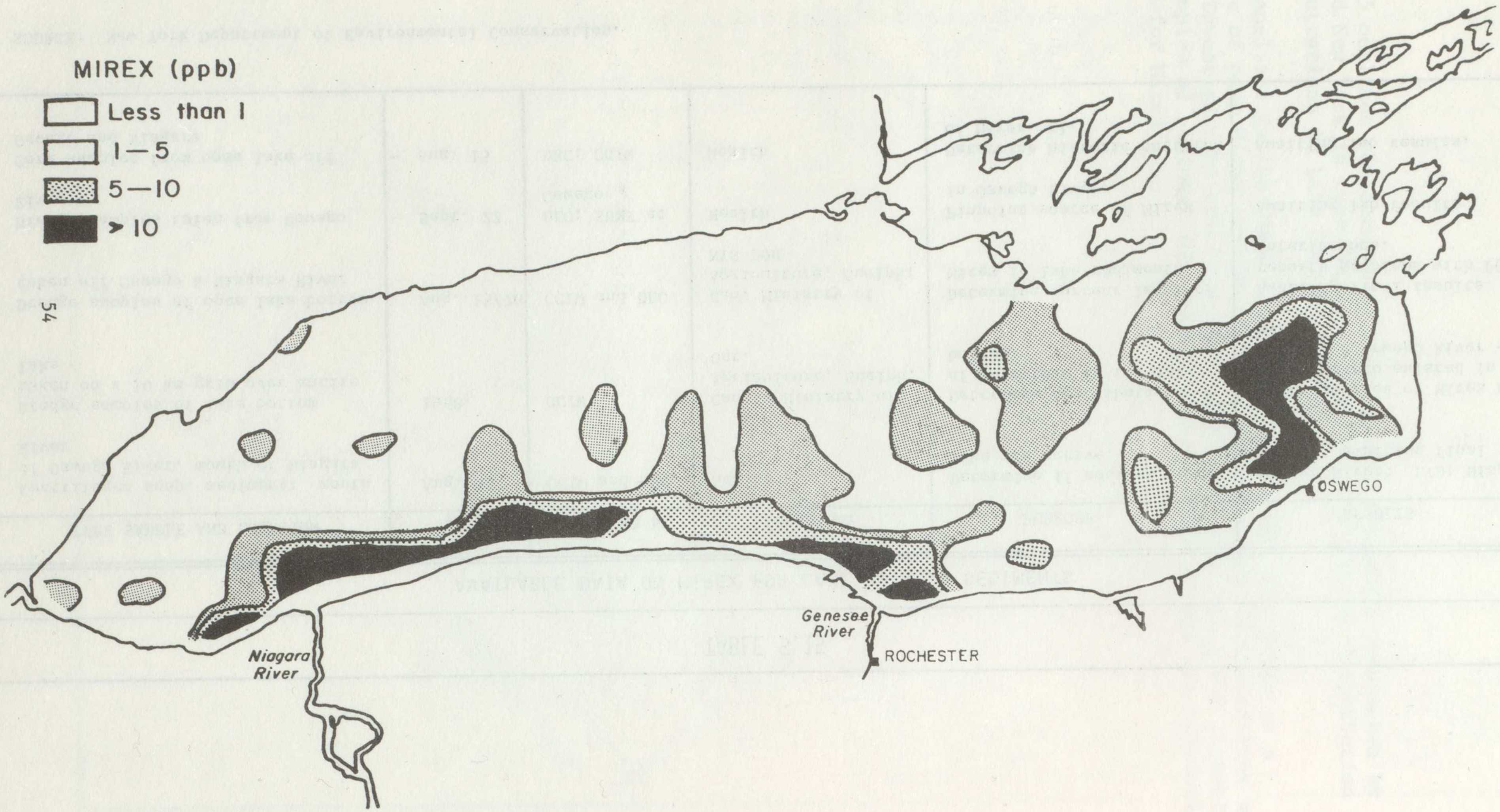
TABLE 5.15					
AVAILABLE DATA ON MIREX FOR LAKE ONTARIO SEDIMENTS					
TYPE SAMPLE AND LOCATION	DATE	COLLECTED BY	LABORATORY	PURPOSE	RESULTS
Centrifuged susp. sediment: mouth of Oswego River, mouth of Niagara River	Aug. 15	CCIW and DEC	Health	Determine if sources to lake are active.	Oswego River: LTD; Niagara River: awaiting final results.
Dredge samples of lake bottom taken on a 10 km grid over entire lake	1968	CCIW	Canada Ministry of Agriculture, Guelph, Ont.	Determine distribution of materials in the lake bottom.	Point sources of Mirex to Lake Ontario existed in the Niagara & Oswego River - aver.
Dredge samples of open lake bottom taken off Oswego & Niagara River	Aug. 15/76	CCIW and DEC	Can. Ministry of Agriculture, Guelph; NYS DOH	Determine current level of Mirex in lake sediments.	Awaiting final results. Lab. reports problems with PCB interference.
Dredge samples taken from Oswego River	Sept. 22	DEC; SUNY at Oswego	Health	Pinpoint source of Mirex in Oswego River.	Awaiting lab results.
Core samples from open lake off Oswego and Niagara	Aug. 15	DEC; CCIW	Health	Determine historic patterns of Mirex pol.	Awaiting lab results.

SOURCE: New York Department of Environmental Conservation.

FIGURE 5.3

MIREX CONCENTRATION IN LAKE ONTARIO

SEDIMENT



SOURCE: Canada Centre for Inland Waters

6. DATA ON WATER QUALITY

New York State Department of Environmental Conservation (NYSDEC) operates a statewide network of 123 water monitoring stations. Forty eight (48) of these stations are located in the Great Lakes drainage basin of New York State. Except for 5 stations on the Niagara River, all stations are on tributaries to the Great Lakes. Analyses for arsenic, copper, lead and mercury are conducted at some stations. No analyses are conducted on a routine basis for organic toxic substances. In September of 1976, the water supplies of 25 communities along Lake Erie - Niagara River - Lake Ontario - St. Lawrence River were sampled and analyzed for Mirex. All results were below the detection limits of 0.02 ppb.

Under the Ontario Ministry of the Environment's Routine River Water Quality Monitoring Program, the following parameters are currently being analysed at all downstream stations designated as "IJC significant tributaries" to the Great Lakes:

- Aldrin/Dieldrin
- Chlordane
- DDT and Metabolites
- Endrin
- Heptachlor
- Lindane
- PCB
- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury
- Zinc
- Copper
- Iron
- Nickel
- Cyanide
- Ammonia

In addition, a number of metals as well as arsenic and cyanide are analysed at select inland stations where a defined problem exists with the potential for causing elevated levels of specific parameters. The past years data will be available in early 1977.

Samples taken from a stream below the Hamilton Township dump site revealed no Polychlorinated Biphenyls. Materials from Borg-Warner of Canada Limited, which has used PBB in one of its minor manufacturing processes, are disposed on this site.

The most recent data on trace metal concentrations in Lake Ontario collected by Environment Canada are summarized in Table 6.1. The cadmium, lead, mercury, zinc, copper and iron data are from a single cruise on the lake in September of 1975 on which a total of 14 stations were sampled. The nickel and chromium data were taken during a cruise in 1975 on which 45 stations were sampled. The arsenic and selenium data (Table 6.2) were collected as part of a survey of arsenic and selenium concentration levels in lakes, rivers and streams in the Ontario region. The trace organic contaminant analyses shown in Table 6.1 were done in 1975 on water samples from 11 stations in the lake.

IFYGL data show that Lake Ontario water contained "total" concentrations (dissolved + particulate) of 28 ng/l, 4.8 ng/l, and 55 ng/l for t-DDT, dieldrin, and PCBs (Table 6.3). Water collected off Oswego contained comparatively high levels of DDT group pesticides, dieldrin, and PCBs, while waters off Hamilton contained higher t-DDT levels, and waters off the mouth of the Niagara River showed higher PCB concentrations.

TABLE 6.1

CONCENTRATION OF TOXIC SUBSTANCES IN LAKE ONTARIO WATER

	No. of Samples	% of Samples Greater than Detection Limit	Minimum Value (µg/ℓ)	Maximum Value (µg/ℓ)	Mean Value (µg/ℓ)
Aldrin/Dieldrin	11	0			<.005
Chlordane	11	0			<.005
DDT & Metabolites	11	0			<.005
Endrin	11	0			<.01
Heptachlor	11	0			<.005
Heptachlor Epoxide	11	0			<.005
Lindane	11	9	< .005	0.008	
Methoxychlor	11	0			<0.05
PCBs	11	0			< .1
Arsenic	30	100	0.2	1.0	0.8
Cadmium	14	7	0.2		
Lead	14	50	1.0	2.0	1.1
Mercury	14	28	.05	.07	.06
Selenium	14	35	0.1	0.4	0.2
Zinc	14	100	2.0	40	7.8
Copper	14	100	1.0	2.0	1.5
Nickel	111	71	< 0.1	4.0	0.8
Iron	14	100	1.5	200	19.1
Chromium	111	70	< .1	1.8	0.5

SOURCE: Canada Centre for Inland Waters

TABLE 6.2

LEVELS OF ARSENIC AND SELENIUM IN WATER FROM LAKE ONTARIO

STATION NUMBER	LATITUDE	LONGITUDE	NUMBER OF SAMPLES	ARSENIC (μg/ℓ)			SELENIUM (μg/ℓ)		
				MAXIMUM	MINIMUM	AVERAGE*	MAXIMUM	MINIMUM	AVERAGE*
2	43°34'24"	79°24'00"	1			1.0			<0.1
3	43°17'18"	79°24'00"	1			1.1			<0.1
5	43°17'36"	79°24'30"	1			0.80			<0.1
6	43°21'36"	78°43'48"	1			0.60			<0.1
9	43°34'54"	78°47'18"	1			1.20			<0.1
10	43°42'24"	79°13'06"	1			0.70			<0.1
12	43°49'48"	78°51'00"	1			1.20			<0.1
15	43°57'00"	78°03'00"	2	1.20	0.80	1.00	0.10	<0.1	<0.1
19	43°35'24"	78°00'42"	1			0.90			0.30
20	43°39'30"	78°48'00"	1			0.80			0.10
22	43°23'00"	88°59'24"	1			0.70			0.10
25	43°39'06"	78°30'00"	1			0.80			0.10
26	43°21'30"	76°57'18"	1			0.90			0.10
29	43°34'06"	76°59'42"	1			0.90			0.10
30	43°45'42"	78°17'00"	1			0.80			<0.1
32	43°48'00"	77°02'24"	1			0.80			<0.1
35	43°26'24"	77°54'00"	1			1.20			0.50
40	43°39'06"	77°36'00"	1			0.90			0.10
45	43°39'00"	77°18'00"	1			0.90			<0.1
50	43°39'00"	77°00'00"	1			0.90			<0.1
55	43°30'24"	76°42'00"	1			0.90			0.10
60	43°43'42"	76°24'00"	1			0.90			<0.1
65	44°00'18"	76°48'00"	1			0.90			<0.1

*Average value or result of one analysis if only one sample collected.

SOURCE: IWD, Environment Canada Scientific Series #58, "Level of Arsenic and Selenium in the Great Lakes Region".

TABLE 6.3

CHLORINATED HYDROCARBONS IN LAKE ONTARIO WATER

(ng/1)

LOCATION	IFYGL STATION IDENTIFIER	STATION DEPTH m	DDE	DDD	DDT	TOTAL DDT	DIELDRIN	PCB
Hamilton	1	33	37.4	2.5	4.5	44	3.1	49
Toronto	8	76	20.5	1.6	1.4	24	3.5	35
Niagara River	13	13	13.9	0.9	2.4	17	2.1	97
Olcott	30	24	26.6	7.1	4.6	38	3.9	44
Cobourg	36	24	45.2	4.5	7.2	57	9.9	45
Rochester	60	25	29.9	<0.5	2.3	32	2.2	40
Deep Hole	75	229	9.4	<0.5	6.5	16	1.3	56
Oswego	90	21	22.4	13.8	12.8	49	12.6	77

SOURCE: EPA-660/3-75-022 "Chlorinated Hydrocarbons in the Lake Ontario Ecosystem (IFYGL)", June 1975.

7. DATA ON BENTHOS AND PLANKTON

In New York, collections for macroinvertebrates are being made through the Division of Pure Waters Biological Monitoring Program in cooperation with the Department of Health's Environmental Health Center. Multi-plate sampling is currently being conducted in the Niagara and Buffalo Rivers. Earlier samples taken from the Genesee River will be analyzed. Additional sampling in the Oswego and St. Lawrence River systems may be conducted as a mechanism for tracking down potential sources of mirex.

IFYGL data show levels of chlorinated hydrocarbons in Lake Ontario net plankton, <u>cladophora</u> and benthic fauna (see Tables 7.1, 7.2 and 7.3 respectively).

In 1975, samples of net plankton (64 μ mesh, mixed zooplankton and phytoplankton) were collected at 11 stations (Figure 7.1) for pesticide and PCB residue analysis (Table 7.4). Residues of DDT, dieldrin and PCBs were found in the net plankton at all stations. Highest concentrations of PCBs were found in the Niagara plume, offshore from Oswego and in Hamilton Harbour.

TABLE 7.1

CHLORINATED HYDROCARBONS IN LAKE ONTARIO NET PLANKTON

(μg/g dry weight)[a]

LOCATION	IFYGL STATION IDENTIFIER	DDE	DDD	DDT	TOTAL DDT	DIELDRIN	PCB
Hamilton	1	4.00	0.09	0.04	4.1	0.24	3.4
Mid-lake West	10	3.52	0.37	0.12	4.0	0.25	10.6
Cobourg	36	3.26	<0.05	<0.05	3.3	<0.05	7.6
Mid-lake	45	1.49	0.07	0.78	2.3	0.16	3.6
Rochester	60	1.19	<0.05	<0.05	1.2	0.02	N.D.
Deep Hole	75	5.89	0.04	<0.05	5.9	0.02	11.8
Mid-lake East	96	2.45	0.09	0.86	3.4	0.18	6.0

[a] N.D. indicates that no determination was made.

SOURCE: EPA-660/3-75-022 "Chlorinated Hydrocarbon in the Lake Ontario Ecosystem (IFYGL)", June 1975.

TABLE 7.4

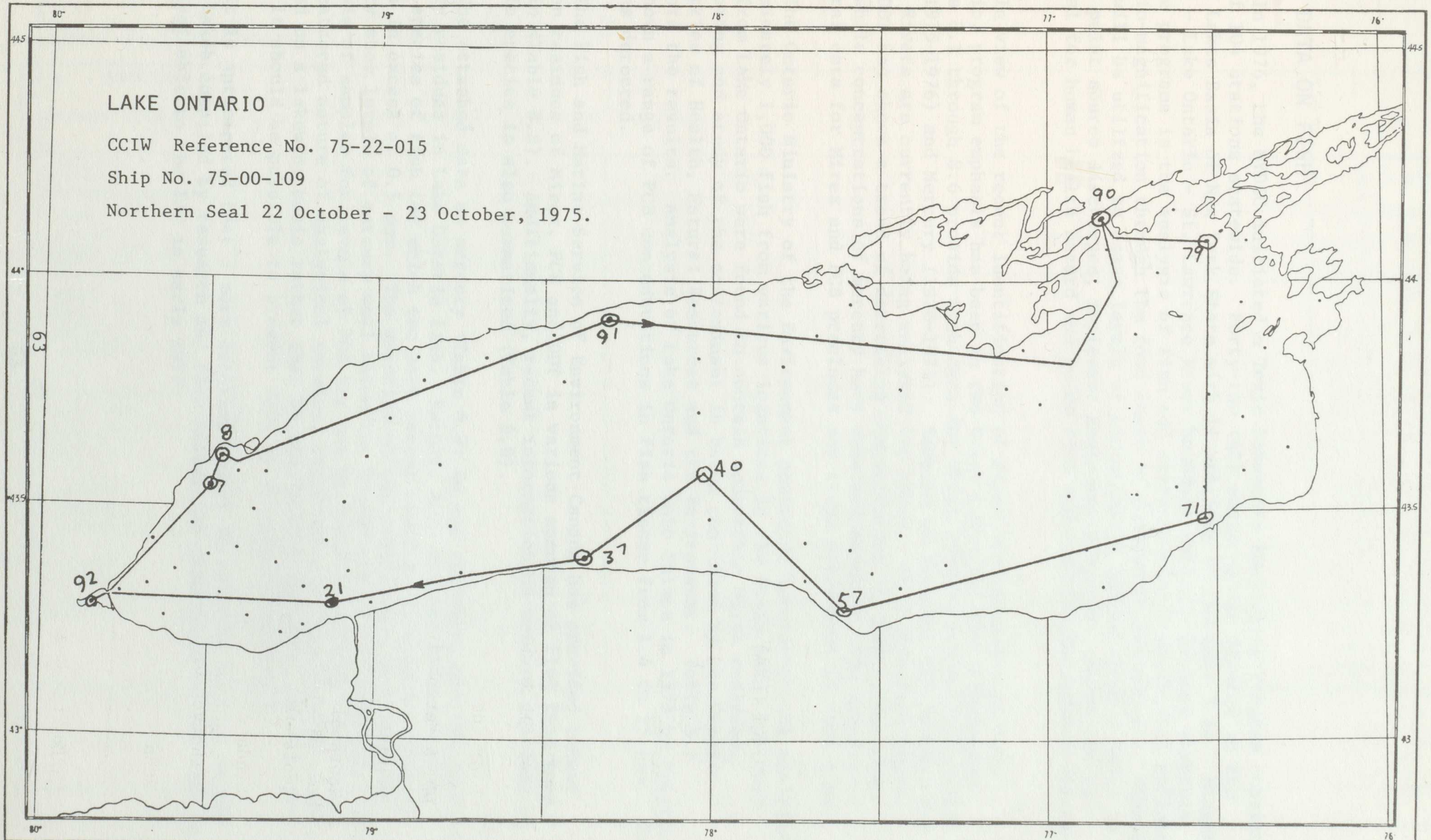
CONCENTRATIONS (μg/g DRY WEIGHT) OF CHLORINATED HYDROCARBONS IN LAKE ONTARIO NET PLANKTON (64 μ MESH) 1975

	NO. OF SAMPLES	% SAMPLE EXCEEDING DETECTION LIMIT	MINIMUM VALUE [μg/g wet weight]	MAXIMUM VALUE [μg/g wet weight]	MEAN VALUE [μg/g wet weight]
Aldrin/Dieldrin	11	91	.010	.41	.136
Chlordane	11	18	.031	.72	.37
DDT & Metabolites	11	91	.094	1.26	.376
Endrin	11	0	less than .01, detection limit		
Heptachlor	11	0	less than .001, detection limit		
Heptachlor Epoxide	11	27	.008	.094	.038
Lindane	11	27	.006	.021	.012
Methoxychlor	11	0	less than .05, detection limit		
PCBs	11	91	.4	6.3	1.88

SOURCE: Canada Centre for Inland Waters

FIGURE: 7.1

LOCATIONS OF PESTICIDES SAMPLING POINTS FOR LAKE WATER AND BIOTA, OCTOBER 22-23, 1975



SOURCE: CCIW

8. DATA ON FISH

In 1976, the NYDEC initiated a Toxic Substance Monitoring Program consisting of 104 stations statewide. Forty-two (42) stations are located in the Great Lakes Basin of New York State with 11 stations in the Lake Erie - Niagara River - Lake Ontario - St. Lawrence River boundary waters. Primary emphasis in the programs is the analysis of fish and wildlife tissue which will reflect the bio-magnification through the food chain of persistent substances. Tissue data will be utilized to assay levels of contaminants and serve as a basis to tract point source discharges, implement abatement programs, assess the potential for human health hazard and guide fish and wildlife management strategies.

In view of the recent identification of Mirex contamination of Lake Ontario, program emphasis has been on the Great Lakes and its tributaries. Tables 8.1 through 8.6 provide fish data for Mirex (1976), PCB's (1970-1976), DDT (1975-1976) and Mercury (1970-1973). Samples of fish for the Genesee and Black Rivers are currently being analysed for Mirex. On a statewide basis, only DDT has shown a trend of decreasing concentration in fish tissue over time while concentrations of mercury have remained constant. The paucity of temporal data for Mirex and PCB precludes any trend assessment at this time.

The Ontario Ministry of the Environment pesticide laboratory has analysed approximately 1,000 fish from various locations in the Great Lakes but only fish from Lake Ontario were found to contain measurable Mirex residues. Monitoring and study of the contaminant is being continued by the Ontario Ministries of Health, Natural Resources and the Environment. Table 8.7 presents the results. Analysis of Lake Ontario Coho Salmon in 1975 by Ontario has shown a range of PCB concentrations in fish tissue from 1.4 to 15 ppm. No PBB was detected.

The Fish and Marine Service of Environment Canada has provided recent data on residues of Mirex, PCB and DDT in various species of fish from Lake Ontario (Table 8.8). Additionally, recent information on mercury residues in certain species is also summarized (Table 8.9).

The attached data on mercury (Table 8.9) do not represent all FMS data on mercury residues in Lake Ontario fish. Rather, they present information on those species of fish for which the most recent testing has revealed mercury levels in excess of 0.5 ppm. The majority of the species in the commercial fishery show levels of mercury well below the health protection standard. The analysis of samples for levels of PCB has not yet been completed. Because of the scattered nature of analytical results, currently available data are summarized on a lakewide basis rather than by statistical district. At a later date, it should be possible to present data by statistical district.

It is anticipated that a more detailed report on residues in fish in the Great Lakes compiled by research and fish inspection components of FMS will be made available to the IJC in early 1977.

TABLE 8.1

SUMMARY OF DEC MIREX DATA FOR LAKE ONTARIO AND TRIBUTARIES

(As of November 16, 1976)

SPECIES	NUMBER ANALYZED	NUMBER ANALYSIS	AVERAGE MIREX CONC. (µg/gm)	MIREX CONCENTRATION RANGE (µg/gm)	AVERAGE TOTAL PCB's (µg/gm)	PCB CONCENTRATION RANGE (µg/gm)	AVERAGE TOTAL DDT AND METABOLITES (µg/g)	TOTAL DDT AND METABOLITE CONCENTRATION RANGE (µg/g)
American eel	4	4	0.14	N.D. - 0.33	6.17	0.12 - 14.77	10.74	0.01 - 1.86
Bass								
Largemouth	7	7	0.01	0.01 - 0.03	1.05	0.09 - 2.92	0.18	0.04 - 0.38
Smallmouth	47	47	0.090	0.01 - 0.31	3.15	0.45 10.93	0.48	0.07 - 1.47
White	14	14	0.07	0.02 - 0.14	2.50	0.83 - 5.17	0.48	0.21 - 0.97
Black crappie	2	2	0.01	0.01	0.70	0.51 - 0.89	0.17	0.12 - 0.22
Brown bullhead	13	13	0.01	N.D. - 0.04	0.89	0.30 - 2.81	0.20	0.06 - 0.49
Muskellunge	2	2	0.08	0.04 - 0.11	2.99	1.93 - 4.05	0.50	0.34 - 0.66
Northern pike	14	14	0.05	0.01 - 0.10	2.04	0.58 - 4.17	0.34	0.11 - 0.81
Perch								
Yellow	19	13	0.02	N.D. - 0.03	0.74	0.22 - 1.72	0.13	0.06 - 0.30
White	38	17	0.109	0.01 - 0.29	5.54	0.86 - 9.70	9.95	0.15 - 2.15
Salmon								
Coho	6	6	0.12	N.D. - 0.23	6.06	1.60 - 10.27	0.93	0.42 - 1.75
Chinook	6	6	0.25	0.13 - 0.36	7.25	2.36 - 13.47	1.04	0.36 - 1.53
Trout								
Brown	37	37	0.095	0.01 - 0.22	5.47	1.31 - 15.14	0.93	0.13 - 2.28
Lake	9	9	0.16	0.03 - 0.42	7.11	1.38 - 18.30	0.91	0.11 - 1.99
Rainbow/Steelhead	1	1	0.11	0.11	10.64	10.64	1.47	1.47
Walleye	4	4	0.01	N.D. - 0.02	0.63	0.08 - 1.21	0.12	0.01 - 0.21

Includes fish collected in July thru September, 1976.

N.D. = None detected

SOURCE: New York Department of Environmental Conservation.

TABLE 8.2

SUMMARY OF AVAILABLE 1976 MIREX DATA (Edible Portion of Fish)

FOR ST. LAWRENCE RIVER*

(As of November 12, 1976)

FISH SPECIES	NUMBER ANALYZED	NUMBER OF ANALYSIS	MEAN MIREX CONCENTRATION (ppm)	MIREX CONCENTRATION RANGE (ppm)	$\bar{X}$ PCB	PCB CONCENTRATION RANGE
Bass						
Smallmouth	46	46	0.06	<0.01 - 0.27	2.25	0.25 - 16.17
Northern Pike	4	4	0.06	0.04 - 0.09	2.07	1.18 - 3.93
Perch						
Yellow	19	12	0.02	N.D. - 0.11	1.72	0.46 - 4.26
White	13	13	0.095	N.D. - 0.19	4.97	0.66 - 11.80
Walleye	4	4	0.05	0.02	3.60	1.41 - 6.52

N.D. = None detected

All analysis by N.Y.S. Department of Environmental Conservation.

Analysis of July thru September 1976 collections only.

TABLE 8.3

MEAN CONCENTRATION OF PCB's AND NUMBER OF FISH ANALYZED IN EDIBLE PORTION FOR YEARS 1970 THROUGH 1975 IN LAKE ONTARIO* (µg/g)

SPECIES	1970**	1971	1974	1975
Coho salmon		6.67 (9)	6.26 (29)	8.41 (19)
Chinook salmon		23.85 (7)	7.15 (9)	8.34 (17)
Rainbow trout			1.97 (3)	5.75 (9)
Brown trout				5.25 (12)
Lake trout			7.69 (4)	9.36 (17)
Smallmouth bass	3.88 (2)			1.81 (7)
Largemouth bass	8.52 (1)			1.79 (5)
Rock bass	1.48 (2)			0.83 (11)
White perch	10.26 (3)			4.17 (27)
Yellow perch				0.38 (25)
Walleye				2.87 (8)
Black Crappie				1.16 (5)
Pumpkinseed				0.03 (10)
Northern pike				2.96 (4)
Brown bullhead				0.57 (10)
American eel				6.28 (2)
Rainbow smelt	2.16 (11)			2.10 (10)
White sucker				3.39 (5)
White bass	30.78 (3)			
Carp	(2.13 (1)			

* - As of 4/2/76.

** - Data not wholly reliable as results reported in several Aroclors.

SOURCE: New York Department of Environmental Conservation.

TABLE 8.4

MEAN CONCENTRATION AND NUMBER OF FISH ANALYZED IN EDIBLE PORTION
FROM LAKE ONTARIO AND ITS TRIBUTARIES, 1975* (μg/g)

SPECIES	ROCHESTER	STONY ISLAND	SANDY POND	OSWEGO	OFF SALMON RIVER	SALMON R. ESTUARY	PULASKI WEIR	CHAUMONT BAY
Coho salmon	3.81 (6)		8.19 (1)		11.28 (10)	7.97 (2)	6.85 (38)	
Chinook salmon	5.69 (3)			23.81 (6)	15.77 (11)	12.04 (37)	4.90 (26)	
Rainbow trout	3.76 (1)		4.57 (1)	3.63 (3)		8.13 (4)		
Brown trout	5.33 (11)		4.39 (1)					
Lake trout	10.99 (1)	7.59 (9)		4.57 (1)	12.26 (5)	13.93 (1)		
Smallmouth bass								1.81 (7)
Largemouth bass						1.79 (5)		
Rock bass			3.58 (1)					0.55 (10)
White perch				5.13 (19)				1.91 (8)
Yellow perch				0.35 (17)				0.43 (8)
Walleye		4.30 (2)		2.39 (6)				
Black crappie			1.68 (3)			1.35 (8)		
Pumpkinseed						0.01 (19)		0.00 (9)
Northern pike	2.99 (2)					1.79 (17)		1.15 (11)
Brown bullhead								0.57 (10)
American eel			6.28 (2)					
Rainbow smelt				2.10 (10)				
White sucker						3.39 (5)		

* - Results of all fish captured in 1975 and analyzed as of 4/2/76.

SOURCE: New York Department of Environmental Conservation.

TABLE 8.5

LAKE ONTARIO - DDT DATA
ROME POLLUTION LABORATORY - 1975 DATA
(edible portion of fish)

SPECIES	NUMBER OF FISH	NUMBER OF ANALYSIS	MEAN	RANGE
American Eel	2	2	1.05	0.38 - 1.71
Bass				
Largemouth	5	1	0.26	0.08 - 0.67
Rock	1	1	0.49	0.49
Black Crappie	8	6	0.26	0.04 - 0.40
Northern Pike	6	6	0.44	0.34 - 0.60
Perch				
White	19	3	1.12	0.62 - 2.45
Yellow	11	2	0.11	0.07 - 0.14
Pumpkinseed	10	2		
Salmon				
Chinook	35	35	1.42	0.38 - 3.55
Coho	38	37	0.93	0.32 - 1.93
Rainbow Smelt	10	4	1.29	0.42 - 2.26
White Sucker	5	5	0.58	0.16 - 1.42
Trout				
Brown	16	16	1.32	0.14 - 4.08
Lake	13	10	1.30	0.27 - 2.82
Rainbow	6	6	1.15	0.14 - 1.94
Walleye	8	5	0.55	0.07 - 1.16

SOURCE: New York Department of Environmental Conservation.

TABLE 8.6

SUMMARY OF MERCURY DATA (edible portion of fish)
LAKE ONTARIO
1970 - 1973

SPECIES SAMPLED

Largemouth Bass, Rock Bass, Silver Bass, Smallmouth Bass, Bluegill, Bowfin, Brown Bullhead, Bullhead, Carp, Channel Catfish, Chinook Salmon, Coho Salmon, Crappie, Black Crappie, White Crappie, Eel, Goldfish, Perch, White Perch, Yellow Perch, Northern Pike, Walleyed Pike, Pumpkinseed, Rainbow Trout, Common Sucker, Redhorse Sucker, White Sucker, Sunfish.

PRINCIPAL CATCHMENT AREAS

Brookwood, Cape Vincent, Irondequoit, Lake Ontario, Oak Orchard, Reed's Bay, Wilson's Bay.

OTHER CATCHMENT AREA

Charity Shoals - Galloop Island, Chaumont Bay, Buck Pond, Grenadier Island, Hamlin Beach, near Henderson, NY, Point Peninsula, near Niagara River, near Rochester, NY, Rome, Stony Island.

	Total No. Fish Analyzed	Mercury-ppm (Avg.)	Mercury-ppm (range)
1970	761	.55	<.05 - 1.7
1971	40	.41	.12 - 0.95
1972	26	.71	.24 - 1.12
1973	25	.72	.25 - 1.99

In 1971 only Rainbow Trout, Coho Salmon, and Chinook Salmon analyzed.

In 1972 and 1973, Smallmouth Bass was only species analyzed.

SOURCE: New York Department of Environmental Conservation.

TABLE 8.7

MIREX IN LAKE ONTARIO FISH

(edible portion)

AREA	SPECIES	NUMBER	MIREX CONCENTRATION (ppm) AVERAGE	HIGH	LOW
LAKE ONTARIO					
Toronto Waterfront Project					
Frenchman's Bay	Carp	4	0.02	0.05	0.01
	Yellow Perch	7	0.04	0.09	0.02
	White Perch	2	0.44	0.50	0.38
	White Bass	7	0.07	0.13	0.04
	Brown Bullhead	4	0.14	0.14	0.08
	White Sucker	2	0.07	0.08	0.05
	Northern Pike	5	0.02	0.04	0.008
	Gizzard Shad	3	N.D.		
	Black Crappie	3	0.01	0.02	0.008
Duffins Creek	Yellow Perch	9	0.25	1.3	0.08
	White Perch	1	0.25		
	White Sucker	8	0.04	0.07	0.03
	Brown Bullhead	10	0.11	0.38	0.04
Etobicoke Cr.	Yellow Perch	10	0.05	0.11	0.02
	Northern Pike	1	0.10		
	White Sucker	13	0.03	0.07	0.002
	White Bass	5	0.09	0.12	0.08
St. Georges	Yellow Perch	1	N.D.		
	Blue Gill	10	N.D.		
	Northern Pike	2	N.D.		
Heart Lake	Brown Bullhead	6	N.D.		
East Point	Brown Bullhead	20	0.06	0.21	0.03
Clairville Res.	White Sucker	5	0.004	0.005	0.003
	Large M. Bass	3	0.004	0.005	0.004
Albion Hills Pond	Yellow Perch	1	N.D.		
	White Sucker	4	N.D.		
	Shiners	2	N.D.		
Humber River	Suckers	16	0.02	0.07	N.D.
Rouge River	Brown Bullhead	43	0.10	0.80	0.03
	Yellow Perch	52	0.08	0.18	0.03
	Northern Pike	3	0.02	0.02	0.02
	White Sucker	2	0.01	0.02	N.D.
LAKE ONTARIO					
Ganaraska River	Cohoe	41	0.24	0.40	0.12
	Rainbow	60	0.03	0.31	0.005
Traverse Shoal	Smelt	5(x5)	0.13	0.21	0.09
Port Dalhousie	Smelt	10(x10)	0.12	0.19	0.06
	Cohoe	10	0.19	0.30	0.12
	Br. Trout	10	0.22	0.35	0.15
Bronte Creek	Smelt	3(x10)	0.12	0.15	0.10
Hamilton Harbour	Smelt	4	0.02	0.04	0.01
	Alewife	13	0.15	0.23	0.04
	Suckers	3	0.02	0.03	0.01
	Perch	3	0.07	0.08	0.01
Humber River	Smelt	7(x5)	0.10	0.12	0.05
Port Hope	Smelt	(3(x4)) (8(x5))	0.20	0.35	0.12
Wilmot Creek	Smelt	10(x5)	0.10	0.14	0.04

These fish were taken between Fall 1975 and Spring 1976 by Ontario Ministry of Natural Resources. Analyses were carried out by Ontario Ministry of Environment Pesticides Laboratory.

() Figures in brackets represent the number of fish included in each composite sample.

N.D. None detected. Detection limit for Mirex is 0.001 ppm.

TABLE 8.8

LEVELS OF MIREX, PCB AND DDT IN SPECIES OF FISH FROM EASTERN PORTION OF LAKE ONTARIO IN 1976
(edible portion of fish)

	CONCENTRATION (μg/g)					
	MIREX		PCB		DDT	
Species	Mean	Range	Mean	Range	Mean	Range
Catfish	.41	.17 - .60	11.58	7.9 - 12.42	2.45	1.60 - 3.51
Pike	.048	.01 - .24	.41	.22 - .89	.051	.03 - .12
Coho*	.085	.03 - .14	3.69	2.0 - 5.38	.685	.42 - .95
Sucker*	.035	.03 - .04	1.005	.96 - 1.15	.18	.13 - .23
Carp	.096	.06 - .14	2.48	1.3 - 3.29	.695	.32 - 1.36
White Perch**	.113	.02 - .61	1.74	0.82 - 2.8	.387	.23 - .73
Eel	.125	.06 - .18	6.68	4.4 - 8.5	1.41	.93 - 2.1
Yellow Perch	.015	.01 - .02	.363	.28 - .52	.048	.03 - .07
Bullhead*	.01	-	.31	.21 - .41	.075	.03 - .12
Smelt	.06	.05 - .07	1.16	1.12 - 1.22	.25	.22 - .29
Sheepshead	.172	.04 - .37	2.98	.89 - 6.6	.48	.14 - 1.1
Rock Bass	.038	.005 -.15	1.59	.11 - 5.21	.363	.01 - 1.18

* - Based on two samples.

** - One Mirex value of 0.61 introduces significant upward bias in the mean. Excluding single high value provides mean of 0.064, range of 0.02 - 0.11. Mean of .113 to be interpreted with caution, as level of .61 for mirex may be analytical artifact.

SOURCE: FMS, Environment Canada.

TABLE 8.9

MERCURY IN VARIOUS SPECIES OF FISH FROM LAKE ONTARIO (1970-75)

Species	Area*	Date	MERCURY (μg/g) Mean	Range
Rock Bass	4C00	1975	0.44	0.18 - 0.73
Catfish	4C00	1975	0.96	0.37 - 1.55
N. Pike	4C05	1973	0.65	-
Rock Bass	4C05	1975	0.47	0.43 - 0.52
Eels	4C05	1975	0.59	0.45 - 0.75
N. Pike	4C06	1975	0.66	-
Eel	4C06	1973	0.65	0.49 - 0.85
Rock Bass	4C06	1975	0.54	-

* - Statistical areas depicted on attached map.

SOURCE: FMS, Environment Canada

Fish intended for commercial sale in Canada have been analysed for several years by the Fisheries Inspection Branch, Fisheries and Marine Services, Environment Canada. At the same time, samples of some commercial fish catches in Ontario are collected by Ontario Ministry of Natural Resources and submitted to Ontario Ministry of the Environment for analysis. The Sports Fisheries Branch of the Ministry of Natural Resources has also collected samples of various fish species from recreational lakes. These fish have been submitted to Ministry of the Environment Laboratories and the Provincial Pesticide Residue Laboratory for PCB analysis. Bioconcentration factors of 6300-71,400 and 12,400 have been reported for PCB accumulation in fish by direct contact and ingestion from water. Juvenile salmon exposed to 1 mg/l Arochlor 1254 solubilized by Corexit 7664 for 24 hours had a total body residue of 60 μg/g.

Table 8.10 represents PCB residue data for coho salmon taken at the mouth of the Credit River in Lake Ontario in the Fall of 1975.

A summary of the range of PCB in fish from various watersheds was prepared by the Water Resources Branch in November, 1975, in response to the announcement by Fisheries and Marine Services of Environment Canada of the new 2 ppm standard for PCB in the edible portion of fish for commercial sale. This summary is presented in Table 8.11.

IFYGL data on the concentrations of t-DDT (sum of DDT, DDE, and DDD), dieldrin, and PCBs (expressed as Aroclor 1254 equivalent) found in whole fish (i.e. wet weight basis) and the extractable fat contents of the fish are shown in Table 8.12. Because chlorinated hydrocarbon levels have been related to the fat content of the fish, these variations likely are further decreased by examining chlorinated hydrocarbon concentrations in relation to the extractable fats contents of the whole fish. Table 8.13 shows t-DDT and PCB levels in fish based on fat content. Such data indicate that the more migratory alewives and smelt accumulate higher t-DDT levels on a fat basis (averages of 36.2 μg/g and 30.5 μg/g) than the less migratory slimy sculpin (16.9 μg/g).

Arsenic and selenium levels in fish from Lake Ontario are in the ranges of 0.003 - 0.12 μg/g (Table 8.14). The results indicate no apparent magnification of either substance from sediments to fish in the lake.

A survey of the Trent System by the Ontario Ministry of the Environment in 1976 utilized rock bass as a biological indicator to identify areas of PCB contamination. Table 8.15 shows the PCB residues from this survey. Samples of spottail shiners (*Notropis hudsonius*), sediments and lakewaters have also been collected at eleven sampling locations on Lakes Ontario, Erie and St. Clair during the fall of 1975 and analysed for chlorinated hydrocarbon residues (Table 8.16). All fish samples contained PCB and DDT residues. Heptachlor epoxide, dieldrin, endrin and chlordane residues were found in some of the collections.

Analyses of samples of Lake Ontario alewife in 1974 by U.S. EPA's Environmental Research Laboratory in Duluth have identified tri-, tetra-, penta-, and hexa-chlorobenzenes.

Organochlorine residuals data in Lake Ontario fish collected and analysed in 1975 by U.S. EPA are shown in Table 8.17.

TABLE 8.10

PCB ANALYSIS RESULTS FOR COHO SALMON TAKEN FROM THE CREDIT RIVER, FALL, 1975

Analyses were performed on edible fillets taken from each fish.

Weight of fish in kilos	Percent fat in edible tissue	PCB level in parts per million
4.3	19	22.5*
4.5	5	5.5*
1.6	18	22.5*
4.9	14	21.0*
4.3	5	4.9*
4.3	14	18.8*
4.4	12	13.0*
2.2	8	12.0*
5.0	4	4.0
2.3	3	3.8
5.2	4	6.3*
2.8	4	2.6
4.0	17	21.8*
4.9	3	4.2
4.5	7	8.3*
2.0	6	5.2*
4.4	12	18.4*
3.5	11	8.5*
4.2	5	16.0*
5.3	7	10.0*
2.5	2	2.7
4.2	15	11.3*
2.2	5	14.1*
3.7	3	5.2*
2.6	11	12.4*
4.7	4	3.7
2.0	11	8.5*
4.2	7	4.4*
2.6	8	6.9*
4.7	2	2.5
5.2	3	3.1
6.3	2	2.9
5.3	2	2.1
4.9	4	3.9
6.3	7	6.8*
5.0	2	2.3
4.8	4	3.4
4.3	4	4.2
5.2	1	2.1
5.1	8	10.7*

* - Far exceed the 2 ppm guideline.
SOURCE: Polychlorinated Biphenyls in the Ontario Environment, MOE Report, July 1976.

TABLE 8.11

PCB'S IN FISH

LAKE	YEAR	AREA	SPECIES	NUMBER OF SAMPLES	% DISTRIBUTION <2 ppm	2-5 ppm	>5 ppm
Ontario	1971	Credit River	Coho Salmon	5	0	0	100
	1974	Credit River	Coho Salmon	7	0	0	100
	1974	Credit River	Brook Trout	6	100	0	0
	1974	Toronto Water- front	Yellow Perch	6	100	0	0
	1974	Toronto Water- front	White Perch	4	0	75	25
	1974	Toronto Water- front	White Sucker	29	90	10	0
	1974	Toronto Water- front	Brown Bullhead	12	84	8	8
	1974	Toronto Water- front	Northern Pike	7	100	0	0
	1975	Credit River	Coho Salmon	42	0	45	55

SOURCE: Polychlorinated Biphenyls in the Ontario Environment, MOE Report, July 1976.

TABLE 8.12

DDT AND PCBs IN LAKE ONTARIO FISH FAT (µg/g)

SPECIES	LOCATION	TOTAL DDT	PCB	PCB/TOTAL DDT
Alewife	Hamilton	18.6	86.7	4.7
Alewife	Olcott	19.2	33.3	1.7
Alewife	Rochester	29.1	128.2	4.4
Alewife	Mexico Bay	31.9	30.3	0.9
Alewife	Prince Edward Pt.	67.5	11.7	0.2
Alewife	Galloo-Stoney	50.8	158.8	3.1
Smelt	Hamilton	33.7	50.4	1.5
Smelt	Olcott	36.7	87.3	2.4
Smelt	Rochester	43.7	79.3	1.8
Smelt	Prince Edward Pt.	17.8	52.1	2.9
Smelt	Galloo-Stoney	20.8	23.3	1.1
Slimy Sculpin	Hamilton	9.6	29.5	3.1
Slimy Sculpin	Olcott	30.2	179.8	6.0
Slimy Sculpin	Rochester	32.8	100.5	3.1
Slimy Sculpin	Mexico Bay	27.0	113.9	4.2
Slimy Sculpin	Prince Edward Pt.	16.2	60.3	3.7
Slimy Sculpin	Galloo-Stoney	10.4	38.7	3.7

SOURCE: EPA-660/3-75-022 "Chlorinated Hydrocarbons in the Lake Ontario Ecosystem (IFYGL). June 1975.

TABLE 8.13

CHLORINATED HYDROCARBONS AND FAT IN LAKE ONTARIO FISH[a]

SPECIES	LOCATION	Fat %	DDE	DDD	DDT	Total DDT	Dieldrin	PCB
			µ/g/ whole fish					
Alewife	Hamilton	3.6	0.46	0.07	0.14	0.67	0.04	3.12
Alewife	Olcott	5.2	0.77	0.07	0.16	1.00	0.03	1.73
Alewife	Rochester	3.4	0.71	0.10	0.18	0.99	0.04	4.36
Alewife	Mexico Bay	3.1	0.79	0.07	0.13	0.99	0.03	0.94
Alewife	Prince Edward Pt.	1.2	0.81	N.D.	N.D.	0.81	0.03	0.14
Alewife	Galloo-Stoney	2.4	0.96	0.08	0.18	1.22	0.04	3.81
Smelt	Hamilton	4.9	1.36	0.06	0.23	1.65	0.04	2.47
Smelt	Olcott	3.0	0.85	0.06	0.20	1.10	0.02	2.62
Smelt	Rochester	4.1	1.37	0.13	0.29	1.79	0.03	3.25
Smelt	Prince Edward Pt.	6.7	0.86	0.10	0.23	1.19	0.06	3.49
Smelt	Galloo-Stoney	6.0	0.91	0.10	0.24	1.25	0.07	1.40
Slimy Sculpin	Hamilton	9.8	0.94	N.D.	N.D.	0.94	N.D.	2.89
Slimy Sculpin	Olcott	5.1	1.10	0.15	0.29	1.54	0.06	9.17
Slimy Sculpin	Rochester	4.3	1.11	0.10	0.26	1.41	0.05	4.32
Slimy Sculpin	Mexico Bay	5.7	1.28	N.D.	0.26	1.54	0.10	6.49
Slimy Sculpin	Prince Edward Pt.	7.6	0.83	0.15	0.25	1.23	0.11	1.58
Slimy Sculpin	Galloo-Stoney	8.6	0.60	0.12	0.17	0.89	0.04	3.33

[a] N.D. - indicates that no determination was made.

SOURCE: EPA-660/3-75-022 "Chlorinated Hydrocarbons in the Lake Ontario Ecosystem (IFYGL), June 1975.

TABLE 8.14

LEVELS OF ARSENIC AND SELENIUM IN FISH FROM LAKE ONTARIO

STATION NUMBER	LATITUDE	LONGITUDE	SPECIES	NUMBER OF SAMPLES	ARSENIC μg/g (wet)			SELENIUM μg/g (wet)		
					MAXIMUM	MINIMUM	AVERAGE*	MAXIMUM	MINIMUM	AVERAGE*
1	43°37'00"	79°27'00"	Alewife	1			0.04			0.07
			Smelt	1			0.04			0.07
5	43°18'30"	78°56'30"	Smelt	1			0.09			0.05
6	43°56'48"	77°48'00"	Alewife	2	0.05	0.05	0.05	0.06	0.06	0.06
7	43°52'48"	77°48'00"	Smelt	2	0.07	0.06	0.065	0.05	0.04	0.04
			Alewife	1			0.07			0.05
			Sculpin	1			0.06			0.05
13	43°22'30"	77°48'00"	Alewife	1			0.10			0.08
			Sculpin	1			0.09			0.04
15	44°04'00"	76°34'00"	Rock Bass	1			0.07			0.08

* Average value of result of one analysis if only one sample collected.

SOURCE: "Levels of Arsenic and Selenium in the Great Lakes Region", IWD, Environment Canada Scientific series #58, 1975.

TABLE 8.15

PCB RESIDUES IN ROCK BASS

TRENT - 1976

LOCATION	FISH SIZE (cm)	NUMBER	PCB CONCENTRATIONS - ppb RANGE	MEAN ± S.D.
Rice Lake, Serpent Mounds	14.6 ± 0.5	10	120 - 340	219 ± 69
Rice Lake, Ottonabee	13.6 ± 1.6	10	120 - 460	308 ± 97
Ottonabee River, Peterborough	13.6 ± 0.8	10	200 - 1650	798 ± 542
Katchawanooka Lake, Lakefield	13.1 ± 0.6	6	N.D. - 100	25 ± 38
Sturgeon Lake, Lindsay	14.7 ± 1.1	6	N.D. - 260	135 ± 102
Balsam Lake, Rosedale	14.2 ± 0.8	8	N.D. - 30	13 ± 13
Lake Simcoe, Talbot River	13.3 ± 0.8	6	N.D. - 20	8 ± 8
Lake Simcoe, Sibbald Point	12.9 ± 0.3	6	80 - 120	93 ± 16
Lake Couchiching, Orillia	15.7 ± 2.2	5	10 - 100	44 ± 35

SOURCE: Ontario Ministry of Environment.

TABLE 8.16

CHLORINATED HYDROCARBON RESIDUES IN SPOTTAIL SHINERS

LAKES ONTARIO, ERIE AND ST. CLAIR - 1975 (NG/G WET WEIGHT)

	NUMBER OF ANALYSES	MEAN FISH LENGTH (T.L.) (mm)	% FAT CONTENT	PCB	ΣDDT	HEPTACHLOR EPOXIDE	DIELDRIN	ENDRIN	CHLORDANE	CHLORDANE
				CONC. ± S.D.	CONC. ± S.D.	CONC. ± S.D.	CONC. ± S.D.	CONC. ± S.D.	CONC. ± S.D.	CONC. ± S.D.
Glenora	5	64 ± 4	2.9 ± 0.3	111 ± 27	41 ± 7	1 ± 0	N.D.	N.D.	N.D.	N.D.
Presqúile	5	60 ± 4	2.7 ± 0.2	520 ± 91	77 ± 12	2 ± 2	1 ± 2	1 ± 0	N.D.	1 ± 1
Darlington	5	64 ± 4	4.9 ± 0.8	420 ± 116	91 ± 29	1 ± 1	N.D.	N.D.	N.D.	N.D.
Frenchman's Bay	5	52 ± 5	2.2 ± 0.3	200 ± 35	46 ± 10	N.D.	N.D.	N.D.	N.D.	N.D.
Toronto Harbour	5	77 ± 3	6.8 ± 0.5	1980 ± 622	221 ± 79	3 ± 2	16 ± 18	3 ± 4	7 ± 6	13 ± 13
Port Credit	5	94 ± 4	7.3 ± 0.9	3845 ± 2247	465 ± 51	1 ± 2	N.D.	N.D.	N.D.	N.D.
Niagara-on-the-Lake	5	56 ± 4	2.3 ± 0.3	690 ± 195	244 ± 52	1 ± 1	N.D.	N.D.	N.D.	N.D.
Port Colborne	5	61 ± 3	1.2 ± 0.3	82 ± 29	32 ± 23	1 ± 1	N.D.	N.D.	N.D.	N.D.
Port Rowan	5	65 ± 4	2.1 ± 0.6	59 ± 29	128 ± 65	1 ± 1	N.D.	N.D.	N.D.	N.D.
Point Pelee	5	63 ± 3	1.8 ± 0.2	844 ± 403	92 ± 22	N.D.	N.D.	N.D.	N.D.	N.D.
Tremblay Creek	4	65 ± 5	3.4 ± 1.9	275 ± 207	81 ± 54	2 ± 1	N.D.	N.D.	N.D.	N.D.
Detection Limits -				10.0	1.0	1.0	1.0	1.0	1.0	1.0

SOURCE: Ontario Ministry of Environment.

9. DATA ON WILDLIFE

Many persistent pollutants present in the Great Lakes accumulate to high levels in top-of-the-food-chain fish-eating birds, of which the Herring Gull is a good example.

Adult gulls from Lakes Michigan, Erie and Ontario remain on their natal lakes throughout the year, but Lake Superior adults migrate to Lake Michigan and Lake Huron adults migrate to Lakes Ontario and Erie during the winter months (Fox 1976). Feeding habits studies show that this species is an excellent indicator of environmental contamination. Residues of mercury and some organochlorine compounds in Herring Gull eggs have been monitored in each of the Great Lakes (Table 9.1).

Residues (primarily PCB, mirex and mercury) were markedly higher in gull eggs from Lake Ontario than from other lakes. The median level for mirex in Ontario eggs is ten times higher than in eggs from any of the other lakes.

Residue levels in Herring Gull eggs in Lake Ontario have remained high and relatively constant since 1972 (Hallett et al 1976) (Table 9.2).

Analysis by GC/MS of adult Herring Gull lipid confirmed the presence of 16 organochlorine pollutants (Table 9.3), four of which were at extremely high lipid concentrations (PCB, 3530 ppm; DDE, 310 ppm, mirex 220 ppm; and a previously unknown photo-isomer, 8-monohydromirex or photomirex, 84 ppm). To date, 13 polynuclear aromatic hydrocarbons have been identified and confirmed at concentrations ranging from 10-300 ppb.

A comparison of organochlorine residues was made between two groups of Lake Ontario fish and Herring Gull eggs (Table 9.4). Four residues, PCB, DDE, mirex, and photomirex, predominated in all species, and levels in coho salmon were 5 times, and in Herring Gull 60-120 times, higher than in alewife and smelt. The ratios of DDE to PCB, mirex, and photomirex (Table 9.5) are not significantly different between the three groups. The similarities of these ratios in both gulls and salmon (an open lake predator feeding on alewife and smelt) suggest that gulls and salmon eat the same food. Organochlorine residues accumulated by wild Lake Michigan Herring Gulls parallelled residues accumulated by caged gulls fed Lake Michigan alewife. The use of Herring Gull eggs as an indicator of trace contaminants in the Great Lakes facilitates identification of those compounds, since residues are generally concentrated at much higher levels than in fish. Direct analysis of water and lower biota for trace contaminants is difficult due to low levels present.

Strong correlations have been established between high concentrations of organochlorine compounds and poor reproductive success for many top predators. Herring Gull studies in 1975 (Gilman et al 1976) revealed almost total reproductive failure of Lake Ontario colonies, characterised by significant decreases in egg hatchability, observed clutch size, and survival of chicks (Table 9.6). The major causes of egg failure were disappearance of eggs from the nest and embryonic mortality (Table 9.7). Qualitative observations made in 1975 and quantified in 1976 indicate that Lake Ontario adult gulls show behavioural abnormalties such as reductions in nest defence and incubation attentiveness.

These behavioural changes permitted an increase in egg predation and the adults failed to provide optimum incubation conditions for the development of the embryo. Fox (1976) quantified an actual decrease in mean egg incubation temperature. Hormonal and genetic changes in breeding adults are implicated as probable causes of the behavioural abnormalities and low egg viability respectively.

Other species of fish-eating birds are also seriously affected. The Double-crested Cormorant population has declined by 90-95% in Lake Ontario and up to 50% in Georgian Bay in eight years. This species suffers from the well-documented thin-eggshell problem (Postupalsky, 1976). Only one small colony of these birds can now be found on Lake Ontario. The Black-crowned Night Heron shows consistently poor reproductive success on Lake Ontario and also lays eggs that readily crack and dent (Price, 1976). The large Common Tern colony at Presqu'ile has now diminished to several pairs.

A recent report by Gilbertson et al (1976) discusses the increased incidence of chick deformities (crossed bills, skeletal anomalies, opthalmic lesions) in several fish-eating bird species (gulls, terns and herons) in the lower Great Lakes. Controlled laboratory studies of birds fed PCB, DDT and DDE have shown these compounds are causally related to embryonic mortality and deformity.

Mirex, the third-largest contaminant in gull eggs in Lake Ontario, is a carcinogen recognized by the U.S. National Cancer Institute. Polynuclear aromatic hydrocarbons and PCB metabolites, all of which have been identified in gull lipid extracts, have also proven to be carcinogenic in mammals, including primates.

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TABLE 9.1

ORGANOCHLORINE AND MERCURY RESIDUE LEVELS[a] IN HERRING GULL EGGS IN THE GREAT LAKES[b] 1974 AND 1975

	NUMBER	DDE	DDD	DDT	DIELDRIN	HEPTACHLOR EPOXIDE	MIREX	HEXACHLORO-BENZENE	PCB[c]	Hg
Lake Ontario	39	22.6 (8.8-35.1)	0.09 (trace-0.83)	0.09 (0.02-1.04)	0.37 (0.08-1.08)	0.12 (0.01-0.36)	5.06 (1.95-18.6)	0.19 (0.01-0.72)	142 (73.8-261)	0.51 (0.29-1.47)
Lake Erie	42	7.04 (3.8-14.3)	0.08 (trace-0.24)	0.04 (0.01-0.15)	0.30 (0.10-0.69)	0.14 (0.04-0.28)	0.31 (0.14-2.19)	0.11 (0.06-0.31)	65.8 (41.2-110)	0.22 (0.11-0.35)
Lake Huron	40	13.8 (5.4-41.9)	0.10 (trace-0.38)	0.08 (0.01-0.32)	0.41 (0.13-0.87)	0.12 (0.04-0.26)	0.56 (0.06-6.92)	0.14 (0.05-0.42)	51.5 (15.4-118)	0.23 (0.11-0.50)
Lake Superior	39	18.6 (8.6-47.1)	0.15 (trace-0.4)	0.12 (0.02-0.58)	0.39 (0.13-1.35)	0.14 (0.07-0.38)	0.66 (0.2-5.17)	0.11 (0.02-0.33)	60 (33.4-148)	0.39 (0.16-0.63)
Lake Michigan	10	31.8 (15.8-145)	trace (trace-0.07)	0.13 (0.07-0.39)	0.48 (0.3-0.92)	0.16 (0.11-0.60)	trace (trace-2.47)	0.04 (0.02-0.14)	91.3 (55.1-395)	N.D.

[a] Median (range) in parts per million, wet weight.

[b] Eggs collected from two colonies in each lake in both 1974 and 1975 except from Lake Michigan where they were from a single colony in 1975.

[c] Polychlorinated biphenyl values based on a 1:1 mixture of Aroc lor 1260:1254.

N.D. Not Determined.

TABLE 9.2

ORGANOCHLORINE RESIDUES (IN PPM) IN HERRING GULL EGGS FROM LAKE ONTARIO

		Mean and Standard Deviation				
YEAR	NUMBER	MIREX	PHOTOMIREX	PHOTOMIREX/ MIREX	DDE	PCB[c]
1972[a]	10	7.2±3.5	3.8±2.0	0.51±0.07	34.0±21.5	204±50
1974[b]	9	6.6±2.8	3.7±1.7	0.56±0.09	23.3±5.5	126±36
1975[b]	10	5.5±2.9	2.9±1.6	0.51±0.09	22.0±5.6	82±16

PPM: μg residue/gram fresh weight egg.

[a] Eggs from Scotch Bonnet Island, near Kingston, Ontario.

[b] Eggs from Muggs Island, Toronto Harbour.

[c] Calculated as Aroclor 1260 according to the method of Reynolds and Cooper (1975).

TABLE 9.3

RESIDUES IDENTIFIED IN LAKE ONTARIO HERRING GULL LIPID

(PPM ON LIPID WEIGHT BASIS)

I. ORGANOCHLORINE COMPOUNDS:

PCB (Aroclor 1260)	(3530 ppm)
Mirex	(220 ppm)
Photomirex	(84 ppm)
HCB	(6.7 ppm)
beta-BHC	(34.6 ppm)
pp'DDT	(3.4 ppm)
pp'DDE	(310 ppm)
pp'DDD	(1.8 ppm)
pp'DDMU	<1 ppm
cis chlordane	<1 ppm
Trans nonachlor	<1 ppm
photo-cis-nonachlor	<1 ppm
oxychlordane	<1 ppm
heptachlor epoxide	(1.0 ppm)
monodechlorinated oxychlordane	<1 ppm
dieldrin	(5.6 ppm)
methoxychlor	<1 ppm

II. POLYNUCLEAR AROMATIC HYDROCARBONS:

a. Confirmed by GC/MS: napthalene, 2-methyl-naphthalene, 1-methylnaphthalene, biphenyl., acenaphthalene, 4-methyl biphenyl, antracene, phenanthrene, 2-methyl plenanthrene, 2-methyl anthracene, 1-methylphenanthrene, 9-methylanthracene, chrysene, 9-dichloromethylene Fluorene.

b. Identified by GC: pyrene, benz(a)fluorene, methylpyrene, benz(a)pyrene, benz(e)pyrene, perylene, 9,10,diphenylanthracene, carbazole.

III. No organophosphorus compounds were found to be present in the Herring Gull lipid samples.

TABLE 9.4

ORGANOCHLORINE RESIDUES IN LAKE ONTARIO BIOTA[a]

(PPM WET WEIGHT)

RESIDUE	ALEWIFE AND SMELT[b]	COHO SALMON[c] MUSCLE	COHO SALMON[c] LIVER	HERRING GULL[d] EGG
PCB[e]	1.11	5.77	2.31	133
DDE	0.19	0.97	0.41	17.4
DDD	0.047	0.11	0.075	0.16
Mirex	0.046	0.23	0.10	4.40
Photomirex[f]	0.034	0.19	0.042	2.04
HCB	0.012	0.097	0.065	0.52
β-HCH	0.002	0.012	0.010	0.078
γ-chlordane	0.010	0.016	0.015	N.D.
α-chlordane	0.023	0.034	0.025	0.12
Oxychlordane	0.010	0.016	0.013	0.197
Heptachlor epoxide	0.003	0.015	0.007	0.122
Dieldrin	0.029	0.087	0.060	0.32
% Lipid	2.34	8.17	6.16	6.33

[a] All values are arithmetic means where several analyses are combined.

[b] Gut contents of coho salmon, n=50, pooled sample, mean weight 13.6 g.

[c] Individual analysis, n=28, mean weight 2393 g; relative std. dev. of mean residue levels: 0.46±5 for muscle, 0.46±14 for liver.

[d] Analysis of 6 pooled samples, 9-10 eggs each, from 4 colonies at the eastern end of the lake (W. Brothers Isl., Pigeon Isl., Snake Isl, and Presquile peninsula); relative std. dev. of mean residue levels: 0.18±0.04.

[e] Calculated as 1:1 Aroclors 1254:1260. This number represents the environmentally stable hexa- and heptachlorobiphenyls, and does not imply all PCBs in these mixtures are present.

[f] 8-monohydromirex. The value for coho muscle is probably too high due to interferences in the chromatographic analysis.

TABLE 9.5

ORGANOCHLORINE RESIDUES IN LAKE ONTARIO BIOTA:

LEVELS RELATIVE TO DDE OF COMPOUNDS RESISTANT TO DEGRADATION

RESIDUE RATIOS	ALEWIFE AND SMELT	COHO SALMON		HERRING GULL EGG
		MUSCLE	LIVER	
PCB:DDE	5.84	5.94	5.63	7.64
Photomirex:DDE	0.179	0.195	0.103	0.117
Mirex:DDE	0.24	0.24	0.24	0.25

TABLE 9.6

REPRODUCTIVE SUCCESS OF GREAT LAKES HERRING GULLS, 1975

	EGGS PER NEST ($\bar{X}$)	HATCHED PER NEST ($\bar{X}$)	REPRODUCTIVE SUCCESS[a] (%)
Granite Island, Lake Superior			
all clutches	3.01	2.38	1.38 ± 0.52
Chantry Island, Lake Huron			
all clutches	3.22	2.38	1.48 ± 0.35
Port Colborne, Lake Erie			
all clutches	3.05	1.93	1.41 ± 0.08
Scotch Bonnet Island, Lake Ontario			
all clutches	3.07	0.59	0.15 ± 0.02

[a] Maximum and minimum estimates of chick survival based on 21 days.

TABLE 9.7

FATE OF HERRING GULL EGGS IN 1975 EXPRESSED AS A PERCENTAGE OF TOTAL OBSERVED

	HATCHED	DISAPPEARED	PIPPED AND CHICK DEAD	ROLLED FROM NEST	CRACKED OR DENTED	EMBRYO FAILED
Granite Island L. Superior (n=301)	79.6	6.1	1.7	1.7	1.3	9.4
Chantry Island, L. Huron (n=406)	72.1	2.2	5.7	6.4	7.9	5.7
Port Colborne, L. Erie (n=168)	63.1*	10.1	3.0	0	7.1	16.7*
Scotch Bonnet Island, L. Ontario (n=129)	18.6**	38.5**	2.3	1.3	4.4	35.1**

* Significantly different from Granite Island and Chantry Island colonies ($P<0.05$, x^2)

** Significantly different from all other colonies ($P<0.001$, x^2)

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GREAT LAKES WATER QUALITY

STATUS REPORT ON ORGANIC AND HEAVY METAL CONTAMINANTS IN THE LAKES ERIE, MICHIGAN, HURON AND SUPERIOR BASINS

TO THE
IMPLEMENTATION COMMITTEE
OF THE
GREAT LAKES WATER QUALITY BOARD

by:
D. Konasewich
W. Traversy
H. Zar

JULY 1978
WINDSOR, ONTARIO

INTERNATIONAL JOINT COMMISSION

GREAT LAKES WATER QUALITY BOARD

October 1978

Implementation Committee

Great Lakes Water Quality Board

International Joint Commission

Members of the Committee:

At the 30th meeting of the Great Lakes Water Quality Board held on December 1-2, 1977, the Implementation Committee was requested to report on the persistent toxic pollutants in the basins of lakes Erie, Michigan, Huron and Superior.

On January 19, 1978, the Implementation Committee requested the undersigned to prepare an inventory of qualitative and quantitative information on the distribution of organic and heavy metal contaminants within the four basins. We have prepared the inventory and are pleased to submit this "Status Report On Organic and Heavy Metal Contaminants in the lakes Erie, Michigan, Huron and Superior Basins".

It is our understanding that under the auspicies of the Implementation Committee, this inventory will be assessed to determine those contaminants which may present a hazard to human health and the environment and to determine if additional programs and measures are necessary to protect public health and resources in the lake basins.

Respectfully submitted,

Dennis E. Konasewich

William J. Traversy

Howard Zar

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ACKNOWLEDGEMENTS

Compilations of data were received from various agencies within the Great Lakes Basin. The efforts of the individuals responsible for the compilations are very much appreciated.

This document certainly could not have been completed within the short timeframe, without the dedicated efforts of Mrs. Jean Laforge and Mrs. Susan Diewart.

SUMMARY

Early in 1978, the Great Lakes Water Quality Board directed its Implementation Committee to prepare a report which would: review available data on the distribution and bioaccumulation of "toxic materials" in the basins of lakes Erie, Huron, Superior and Michigan; define the necessary future programs to assess the degree of contamination in the basins; and, recommend future data collection, financial and technical assistance to conduct necessary programs and measures to protect the public health and resources of lakes Erie, Huron, Superior and Michigan. A report for Lake Ontario was prepared in 1976.

This report to the Implementation Committee is an inventory of organic and heavy metal contaminants which have been detected in the basins of lakes Erie, Huron, Superior and Michigan. Subsequently, under the auspicies of the Implementation Committee, the identified contaminants will be evaluated to determine which, if any, may have potential effects on human health and the environment. Recommendations for future programs will then be developed.

INTRODUCTION

At the September 1976 meeting of the Water Quality Board, the issue of toxic materials in Lake Ontario was discussed at some length with particular emphasis on the immediate problems relating to mirex, kepone, PCBs and other identified pesticides. The State of New York suggested to the Water Quality Board that a reference or work group be established to address the following areas:

1. Review of available data on the distribution and bioaccumulation of toxic materials.

2. Coordination of future programs to assess the degree of contamination of Lake Ontario.

3. Recommendations regarding future data collection, financial and technical assistance to conduct necessary programs and measures to protect the public health and resources of Lake Ontario.

In response to the State of New York's suggestion, the Water Quality Board directed the Implementation Committee to review the available data on the distribution and bioaccumulation of toxic materials in Lake Ontario. It also directed the Committee to investigate the feasibility of utilizing the existing committee structure of the Board to undertake items #2 and #3.

In its consolidation of available information on the bioaccumulation and distribution of toxic substances in Lake Ontario, the Committee limited its efforts to 50 specific substances. The substances included those for which water quality objectives have been recommended by the Water Quality Board to the International Joint Commission, and substances obtained from lists of: the Environmental Contaminants Control Branch (Canada); the Court Settlement Agreement between U.S. EPA and the Natural Resources Defense Council; and, the Ontario Ministry of the Environment. The compounds all met the following four criteria:

1. They were identified in Lake Ontario biota, rainwater, effluents, sediments and water.

2. There was evidence that they could bioaccumulate. Partition coefficients were generally used to estimate bioaccumulation potential.

3. Each substance must be toxic to either fish, man or wildlife or be a mutagen, carcinogen, or teratogen.

4. The substances must be persistent.

Following the review of the available data on the distribution and bioaccumulation of the 50 identified toxic substances within the Lake Ontario Basin, the Implementation Committee in December 1976 made seven recommendations to the Water Quality Board. Among the recommendations were: the need for monitoring to establish trends of specific toxic substances levels in Lake Ontario; the need for establishing action levels (of the 50 substances) by environmental health agencies for the protection of human health from the substances identified; and, the need for close coordination between the air, water and solid waste programs. Subsequently, the recommendations were transmitted to the International Joint Commission by the Water Quality Board in July 1977. The recommendations are detailed in the Water Quality Board's 1976 Annual Report to the IJC and in the Board's Appendix E, entitled "Status Report on the Persistent Toxic Pollutants in the Lake Ontario Basin."

Early in 1978, the Great Lakes Water Quality Board directed its Implementation Committee to initiate the preparation of a similar report for the other four Great Lakes - Erie, Huron, Superior and Michigan. Each jurisdiction within the Great Lakes Basin was then requested to provide qualitative and quantitative information on organic contaminants and heavy metals which the jurisdictions have identified in point sources, atmospheric sources, sewage sludges, runoff, sediments, water, benthos, plankton, fish and wildlife within the basins of the four lakes. Requests were also made to various research laboratories. On the basis of the responses to the above requests and on the basis of a search of the available scientific literature, information was assembled on contaminants found within the four lakes and subsequently published within this Report.

Originally the intent of this Report was to focus only on the fifty substances identified within the Lake Ontario report. However, the responses of the jurisdictions and the published scientific literature contained information on the presence of an extensive number of additional compounds, many for which there is minimal information on their possible environmental and health effects. As a result, this report outlines the additional contaminants so that future evaluations may be made to determine which, if any, present a hazard to the environment and/or to human health. Tables I and II show the distributions of the 50 compounds within the basins of the four lakes. Lake St. Clair, and the Detroit and St. Clair Rivers are listed in a separate category. Table III shows the other contaminants which were identified.

With regard to this Report, there are several major points which must be highlighted:

1. Due to the considerable amount of information received, a review and analysis of the data could not have been completed within this reporting period. No effort was made to assess the quality of the data. This document only serves as an inventory of information for subsequent review by the Implementation Committee, its Subcommittees, the Committee on the Assessment of Health Effects of Great Lakes Water Quality, and possibly the Research Advisory Board. The groups may, for example, determine: which, if any, of the compounds listed in Table III are harmful to aquatic biota, wildlife or human health; the possible sources of harmful compounds; and, the adequacy of existing monitoring programs. The Chemical Abstracts Service Registry

Numbers (CAS) noted within the tables will enable computer searches for information on toxicity, carcinogenicity and chemical properties, to aid in the evaluation process. The Committee on the Assessment of Health Effects of Great Lakes Water Quality initiated its efforts during October, 1978.

2. With regard to the large number of compounds listed in Table III, the Great Lakes Water Quality Board in its Report to the Commission in July 1978 concluded:

(a) The proliferation of hitherto-unreported chemical compounds discovered in the Great Lakes ecosystem in recent years is probably related to the increasing skills of analytical chemists to identify them rather than to any real, sudden increase in their presence in the ecosystem. As analytical methods become more sophisticated, this trend will continue.

(b) Such information on contaminants provides a basis for assessing potential effects on human health and the environment. This establishes a baseline for future studies to determine if concentrations of individual chemicals are increasing over a period of time and can aid in determining the source of the compound in question.

(c) Many of the compounds detected are known to have the potential to be detrimental to human health or otherwise affect ecosystem quality. However, such potential may be realized only under exposure conditions far removed from those experienced under present conditions in the Great Lakes Basin.

(d) Although there have been advances in the science of toxicology such that a number of screening techniques indicative of potential toxicity have been developed, definitive studies to characterize the potential of a chemical to produce adverse effects remain expensive, time-consuming and demanding of facilities and expertise which is available only to a limited extent.

(e) As a consequence of this growing list of contaminants, vigorous application of toxic substance legislation introduced in Canada and the United States represents the most effective mechanism to protect environmental health and quality. Continued surveillance efforts will assure that trends and levels of contaminants will be monitored.

3. Many of the compounds in Table III, such as the polyaromatic hydrocarbons, fatty acids and glycolates may be naturally occurring.

4. This Report attempts to identify as many contaminants as possible. There is much information on contaminant levels (quantitative data) which is not within this Report.

5. The data within this Report was and is publicly available. However, due to the considerable amount available from many sources, it is expected that some of the data will be new to many of the investigators working within water pollution control efforts.

TABLE I[1]

SUMMARY OF THE DISTRIBUTION OF CONTAMINANTS FOR WHICH GREAT LAKES WATER QUALITY OBJECTIVES HAVE BEEN DERIVED

E - Lake Erie
D - St. Clair River, Lake St. Clair
    Detroit River
H - Lake Huron
S - Lake Superior
M - Lake Michigan

	Chemical Abstracts Reg. Nos.	MEDIA AND LAKE BASIN						
		WATER	SEDIMENT	AIR	DISCHARGES +SLUDGE	BENTHOS PLANKTON	FISH	WILDLIFE
Organic Substances								
Aldrin	309002	HS			EDHM		EHS	
Chlordane	57749	SEHD	ED		EDHM	E	EHSMD	ES
Dieldrin	60571	HSMED	EHSMD	EHS	EDHM	HSE	EDHSM	EHSM
DDT and metabolites	50293	HSMED	DSMEH	ESHD	EM	SEH	EDHSM	HSM
Endrin	72208	SE			EDHM	E	HS	
Heptachlor	76448	HS			EDHM			
Heptachlor epoxide	13366680	SEDH	ED	E	EDHM		EDHS	EHSM
Lindane	58899	HSE		EHS	EDHM		HS	
Methoxychlor	72435	S		EHS	DM		HS	
Toxaphene	8001352	S					HS	
Phthalic acid esters*		EDHSM	SHED		EDHM	S	HSM	
Polychlorinated Biphenyls	27323188	EHSMD	EDHSM	EHSMD	EDHSM	EHS	EDHSM	EHSM
Kepone								
$C_{10}Cl_{12}$ (Mirex and Dechlorane)		E				E	S	EHSM
Inorganic Substances								
Arsenic	7440382	EDHSM	EDHSM	MDHE	DSM	M	EHSM	
Cadmium	7440439	EDHSM	EDHSM	EHSMD	EDSM		EHS	
Lead	7439921	EDHSM	EDHSM	EHSMD	EDSM		EHSM	
Mercury	7439976	EDHSM	EDHSM		EDSM	EM	EDHSM	ESM
Selenium	7782492	EDHSM	EH		SM	EM	EHS	
Zinc	7440666	EDHSM	EDHSM	MEHD	EDSM	M	EHSM	

*See individual compounds in Table III

(1) The substances listed in Table I and Table II are the 50 "persistent toxic pollutants" of concern identified by the Great Lakes Water Quality Board in its 1976 report to the International Joint Commission.

TABLE II

CONTAMINANTS OF CONCERN(1) IDENTIFIED BY THE GREAT LAKES WATER QUALITY BOARD IN 1977

E - Lake Erie
D - St. Clair River, Lake St. Clair Detroit River
H - Lake Huron
S - Lake Superior
M - Lake Michigan

	Chemical Abstracts Reg. Nos.	MEDIA AND LAKE BASIN: WATER	SEDIMENT	AIR	DISCHARGES +SLUDGE	BENTHOS PLANKTON	FISH	WILDLIFE
Organic Substances								
Benzene	71432	EM			D			
1,2-1,3-1,4-dichloro-benzenes	541731 95501 106467	ME					HM	
Trichlorobenzene	87616				M		HSM	S
Tetrachlorobenzene	634662 634902 95943						EHS	S
Pentachlorobenzene	608935						EHS	S
Hexachlorobenzene(HCB)	118741	E	M	EHS	D		EHSD	EHSM
p-Bromoanisole								
Chlorinated Napthalene								
Methylnaphthalene	1321944				D		HDS	
Phenol	108952	EDHSM	H		SMH			
Trichlorophenol	95954 88062				M		M	
Pentachlorophenol	87865	E			SM		H	
Tetrachlorophenol	25167833				SM		M	
Carbon tetrachloride	56235	E			D			
Chloroform	67663	EDHM			D			
Bromoform	75252				D			
Tetrachloroethylene	127184	EM			D			
Chlorinated Styrenes (Octa & Poly)							EDHS	
Hexachlorobutadiene (HCBD)	87683	E	M				EHS	
Toluene	108883	M			DM			
Pentabromotoluene								
2,3,7,8-Tetrachloro-dibenzo-p-Dioxin (TCDD)							H	
αBHC (1,2,3,4,5,6-Hexachlorocyclo-hexane)		S		HS			SH	M
β-BHC (Benzene Hexa-chloride)				HE		E	SEM	HS
Polybrominated Biphenyls	36355018 136544096	H	H				HS	H
Chlorinated Terphenyls	31372357 27043045				D			
Polynuclear Aromatic Hydrocarbons - See Table III for individual compounds								
Inorganic Ions								
Nickel	7440020	EDHSM	EDHSM	EDHSM	EDSM		EHS	
Copper	7440508	EDHSM	EDHSM	EDHSM	EDSM	SMH	EHS	
Chromium	7440473	EDHSM	EDHSM	MDE	EDSM	MH	EHSM	

(1) In addition to those listed in Table 1.

TABLE III

LIST OF ADDITIONAL ORGANIC COMPOUNDS AND HEAVY METALS IDENTIFIED IN FOUR GREAT LAKES BASINS

E - Lake Erie
D - St. Clair River, Lake St. Clair, Detroit River
H - Lake Huron
S - Lake Superior
M - Lake Michigan

	Chemical Abstracts Reg. Nos.	MEDIA AND LAKE BASIN: WATER	SEDIMENT	AIR	DISCHARGES +SLUDGE	BENTHOS PLANKTON	FISH	WILDLIFE
Organic								
6,8,11,13 Abietate-traen-18-oic acid	514103				S			
Abietic acid					S			
Acenaphthene	83329						D	
Acetone	67641	M			DM			
Acetophenone	48862	M						
Acetovanillon	498022				SM			
Alachlor		HE						
Alkyl benzene($C_{10}H_{14}$)	28729546				S			
	104518							
	25340174							
Aniline	62933				M			
Anthracene	120127						D	
Arachidic acid	506309				S			
Atrazine	1912249	HDE	EH		M			
Behenic acid	112856				S			
Benzanthrene	92240	M						
Benzo(b)fluoranthene				H	D			
Benzo(j)fluoranthene		E						
Benzo(k)fluoranthene		E		H	D		D	
1,2-Benzofluorene	238846						D	
2,3-Benzofluorene	243174						D	
Benzoic acid	54850				SM			
Benzo(rst)pentaphene				DH				
Benzo(ghi)perylene		E		DH				
Benzo(a)pyrene	50328	E		DH			D	
Benzo(e)pyrene	192972			DH				
Benzothiazole	95169				M			
Benzyl alcohol	100516				M			
Benzylbutyl phthalate		M						
Biphenyl	92524						DH	
Borneol	507700				S			
Bromobenzene	108861	M						
Bromochloroethane	25620546	M			D			
Bromodichloromethane	75274	DM			S			
Butadiene	106990				D			
Butane	106978	M						
tert-Butanol	75650				D			
Butene	106989	M						
But-2-en-1-ol	6117915				D			
Buten-3-yne	789974				D			
Butylbenzyl phthalate	85687	M						
t-Butyl pyrocatechol					S			
Butyl phthalyl butyl glycolate		ME						
Caffeine	58082	M						
Camphene	79925				S			
Camphor	464493	EDHM						
Carbofuran	153662	HE						
Carbon disulphide	75150				D			
Chloroaniline	108429				M			
	95512							
	106478							
Chlorobenzene	108907	M						
Chlorodehydroabeitic acid	28243632				M			
Chlorodibromomethane	124481	D						
bis-2-Chloroethyl ether	111444				D			
bis-(2-Chloro isopropyl) ether	108601	E						
Chloronorbornenes	15019713						HS	

	Chemical Abstracts Reg. Nos.	WATER	SEDIMENT	AIR	DISCHARGES +SLUDGE	BENTHOS PLANKTON	FISH	WILDLIFE
Chloroindole	16863960				M			
	25235852							
	17422321							
	17422332							
	694939							
Chloro-oxo-Dehydro abietic acid	38012021				M			
2-(4-Chlorophenoxy) 2-methyl propionic acid	882097				M			
Chloropropene	590216				D			
Chloropropiophenone	6084179				M			
	736594							
	6285058							
Chlorosyringaldehyde					M			
Chlorotoluene	108418				M			
	95498							
	106434							
(4-Chloro-o-toloxy) acetic acid [MCPA]	94746	EH						
Chloroveratrole	16766271				M			
Chloroxylenes	25323415				M			
Chlorpyrifos		DE						
Chrysene	218019						D	
Coronene	191071						D	
Cresol	108394				M			
	95487							
	106445							
Cumene	98828				D			
Cyclohexane	110827				D			
Cyclopentane	287923	M						
Cyprazine		HDE						
Decachlorobiphenyl	2051243				D			
Decanols	1740198				DM			
N-Decylcyclohexane		E						
Decanoic acid	334485				M			
Dehydroabietic acid	1740198	S	S		SM	S		
Dehydrodiconiferyl alcohol	4263870				S			
Diazinon	333415	EH						
Diazobenzene	103333				M			
Dibenz-[a,h]-anthracene	53703						D	
Dibenz(def,mno) chrysene				DH				
Dibenzo(b,def)chrysene				DH				
Dibromo chloroethane		M						
Dibromo chloromethane	124481	EM						
Dibromoethane	25620626	M						
Dibromomethane	74953				D			
Dibutylphthalate (DBP)	84742	EDHSM	HE		EDHM		HS	
Dichlorobenzidine	84684				M			
	91941							
Dichlorobenzophenones	5293970				M			
	90982							
	7094340							
Dichlorobutane	26761819	M						
Dichlorobutadienes	6061069				D			
	3574401							
	2984421							
Dichlorobutene	11071968	D						
Dichlorodiene resin acids					M			
Dichlorodifluoromethane	75718	E			S			
Dichloroethane	29047827	ME			D			
1,2-Dichloroethane	107062	E			M			
1,2-Dichloroethylene	540590				DM			
Dichloroethylene	25323302	M						
Dichloroguaiacol	60546114				M			
	60546056							
Dichloromethane	75092	EM			DM			

	Chemical Abstracts Reg. Nos.	WATER	SEDIMENT	AIR	DISCHARGES +SLUDGE	BENTHOS PLANKTON	FISH	WILDLIFE
3,6 Dichloro-2-methoxybenzoic acid (dicamba)	1918009	E						
Dichlorophenol	25167811				M			
2,4(Dichlorophenoxy) acetic acid	94757	EDH	HD					
N-(3,4-Dichlorophenyl) -N,N'-diethylurea	15545503				D			
Dichloropropane	26638197	M			D			
Dichloropropene	26952238				D			
Dichloroveratrole	2772465				S			
1,2-Diethoxyethane	629141	M						
N,N-Diethyl aniline	91667				M			
Diethyl benzene	25340174				D			
Diethyl ether	60297	M			D			
Diethylhexylphthalate (DEHP)	117817	EDHSM	SED		DE		HSM	
Diethyl phthalate	84662	M			EDHM		HSM	
Dihexyl adipate	110338	S						
Diisobutyl phthalate	84695	M						
Diisopropyl ether	108203	M						
Dimethoxy acetophenone	21160269				M			
	829209							
	1201383							
	2040042							
	1131620							
3,4-Dimethoxyaceto-phenone	1131620				S			
Dimethoxymethane	109875	H						
Dimethyl adipate	627930						*	
N,N-Dimethyl aniline	121697				M			
Dimethyl biphenyl	28013118	M						
2,5-Dimethyl decane	17312504	E						
Dimethyl disulfide	624920	H			M			
Dimethyl naphthalene	28804888				D			
Dimethyl phthalate	131113				S			
Dimethyl sulfide	75183	H			M			
2,6-Dimethyl undecane	17301234	E						
Dioctyl phthalate	117840		S		S	S		
Dioxane	123911	M						
Diphenylacetaldehyde	947911							
-Monochloro derivative	905152				M			
	52999732							
-Dichloro derivative	51559014				M			
	34877753							
	18164506							
-Trichloro derivative	39249735				M			
	59612598							
Diphenylamine	122394						*	
Diphenylcumylphenyl-phosphate			M		M		M	
Diphenyl methane	101815						*	
Diphenylnonylphenyl-phosphate			M		M		M	
Dodecanoic acid	334485				M			
Dodecanol	112538				M			
Endosulfan (α,β)	115297	HDE	DE	EHS				
Epijuvabione (methyl ester)	26462748				S			
EPTC (eptan)		E						
Ethion	563122	DH						
2-(2-(2-Ethoxyethoxy) ethoxy) ethanol	112505				M			
N-Ethylaniline	103695				M			
Ethyl benzene	100414	M			M			
Ethyl chloride	75003				D			
2-Ethyl-1-hexanol	104767				M			
Ethyl palmitate	628977				S			
Fenchyl alcohol	1632731				S			
Fluorene	86737						D	
Fluoranthrene	206440	E					D	

	Chemical Abstracts Reg. Nos.	WATER	SEDIMENT	AIR	DISCHARGES +SLUDGE	BENTHOS PLANKTON	FISH	WILDLIFE
Fluorodichlorobromomethane	353582	M						
Formaldehyde	50000				D			
Furfural	98011	M						
Guaiacol	90051				S			
Heptachlorostyrenes	29086382						E	
	29086393							
	29082755							
Heptadecane							M	
Heptadecanoic acid	506127	S			SM			
Heptanoic acid	111148				M			
Heptene	25339564	M						
Hexachlorobutene	930809	E						
	18766875							
Hexachloroethane	67721	E			D			
Hexachlorostyrene	53660472						E	
Hexadecane	544763	E						
Hexadecanoic acid	57103				M			
Hexane	110543	M						
Hexanoic acid	142621				SM			
Hexene		M						
Homovanillin	5703242				M			
Hydroxybenzothiazole	13599843				M			
Hydroxymethoxyacetophenone	552410				M			
	703980							
	705157							
	703231							
4-Hyrdoxy-3-methoxy phenyl acetic acid	306081				S			
4-Hydroxy-3-methoxypropiophenone	1835149				S			
Indeno (1,2,3-cd) pyrene		E						
Iodo dichloromethane	594047							
Isoborneol	124765				M			
Isopiramic acid	5835267				S			
Lauric acid	143077	S						
Leptophos				D				
Lignoceric acid	557595				S			
Limonene	138863				S			
Linoleic acid	60333	S			S			
Malathion	121755	E						
o-Methoxyphenol	90051				S			
Methoxyphenol	26638039				M			
2-Methoxy-4-propyl phenol	2785877				S			
Methyl abietate	127253	M			S			
1-Methyl anthracene	610480						D	
2-Methyl anthracene	613127						D	
9-Methyl anthracene	779022						D	
Methyl arachidate	1120281	M						
Methylbenzothiophene	1195148						H	
Methyl-t-butyl ketone	591786	E						
Methyl-2(4-chlorophenoxy) butanoate	94815	M						
Methyl dehydroabietate	1235741	M			S			
Methyl dichlorophenyl ether	54518159	M						
6-Methyl-1,2-dihydronapthalene	2717477				D			
Methyl 9,10-dihydroxystearate	1115011				S			
4-Methyl-2-ethyl-1,3-dioxolane	4359460	M						
10-Methyleicosane	55193561	E						
Methylene chloride	75092	E						
Methyl-2-ethyl hexanoate	32579810	EDM						

	Chemical Abstracts Reg. Nos.	WATER	SEDIMENT	AIR	DISCHARGES +SLUDGE	BENTHOS PLANKTON	FISH	WILDLIFE
Methyl ethyl ketone	78933				D			
Methyl isobutyl ketone	108101	M						
Methyl isopimarate	1686620				S			
Methyl 7-ketodehydro-abietate	24267876				S			
Methyl laurate	11820							
Methyl linoelaidate					S			
Methyl linolenate	301008				S			
Methyl methacrylate	814788	M						
Methyl myristate	124107	DM						
Methyl neoabietate					S			
2-Methyloctadecanoic acid	7217836	S			S			
Methyl 7-oxodehydro-abietate	17751369				S			
Methyl palmitate	112390	EDHM			S			
Methyl pentachloro-phenyl ether	1323214	M						
2-Methyl pentanoic acid	97610				S			
Methylphenanthrene, 1 and 2	28652815						DHS	
2-Methyl phenol	95487				S			
Methyl pimarate $C_{21}H_{32}O_2$	3582261				S			
Methyl sandaracopi-marate	3582261				S			
Methyl stearate	112618	EDHM			S			
Methyl tetrachloro phenyl ether	53452816	M						
Methyl tetrahydro-furan	25265683	M						
Methyl thiobenzo-thiazole	2254946	E			M			
	2268793							
	54237364							
Methyl trichloro-phenyl ether	6130752	M						
Metribuzin	21087649	HDE						
Monochlorodiene resin acid					M			
Monochlorophenol	25167800				M			
Myristic acid	544638	S			S			
Naphthalene	91203	M			D		DHS	
Naptho(1,2,3,4,def) chrysene				DH				
Neopentane	463821	M						
Nonachlor, trans and cis	3734494						EDHSM	
Nonanoic acid	112050				M			
Nonene	27215958	M						
Octachloronaphthalene	2234131				M			
Octadecanoic acid	57114				M			
Octadecanol	112925				D			
Octanoic acid	124072				M			
Oleic acid	112081	S			S			
7-Oxodehydroabietic acid	18684554				S			
Oxychlordane	21858413						HS	SM
Palmitic acid	57103	S	S		S	S		
Palmitoleic acid	2091294	S			S			
Pentachloroaniline	527208						*	
Pentachloroanisole	33104175				M		DH	S
	1825214							
Pentachlorobutadienes	5659449	E					E	
	21400419							
	21484059							
	21484048							

		MEDIA AND LAKE BASIN						
	Chemical Abstracts Reg. Nos.	WATER	SEDIMENT	AIR	DISCHARGES +SLUDGE	BENTHOS PLANKTON	FISH	WILDLIFE
Pentachlorobutene	30353549	E						
Pentachloroethane	76017	E						
Pentachloronor-bornene	18317936						E	
	21657705							
	32763772							
	32763749							
	18317903							
	18317947							
Pentachloropropane	16714684						E	
	15104617							
	21700312							
	23153233							
Pentachlorotoluene	877112						*	
Pentadecanoic acid	1002842	S			SM			
Pentane	109660	M						
3-Pentanone	966220				M			
Pentene	109671	M						
	109682							
Perylene	198550			DH			D	
Phenanthrene	85018						DHSM	
Phenylacetic acid	103822				M			
Phenylacetylene	536743				D			
1-Phenyl naphthalene	605027						D	
o-Phenyl phenol	92693				M			
Phenylpropionic acid	501520				M			
Photomirex								EHSM
Pinene, α and β	80568				SM			
Prometone		HDE						
Propanol	71238				D			
Propylbenzene	103651				D			
Propyl toluene	28729546				D			
Pyrene	129000	M					D	
Safrole	94597				S			
Salicylic acid	69727				M			
Sandaracopimaric acid	471749				S			
Silvex	93721	S						
Simazine	122349	HDE						
β-Sitosterol	83465				S			
Stearic acid	57114	S			S			
Styrene	100425	E			D			
Syringaldehyde	134963				M			
Terpene		HM						
Terphenyl	26140603							
C_{10} Terpineol	8000417	M						
C_{15} Terpineol		DM						
α Terpineol	98555				SM			
Terpinene	99854				S			
	8013001							
Tetrachloroanisole	53452816						M	
Tetrachloroanthracene	25283027						*	
Tetrachlorobutadienes	921095	E					E	
	1637316							
	18149763							
Tetrachlorodiene resin acids					M			
Tetrachloroethane	79345	EMD			D			
Tetrachloro guaiacol	2539175				M			
Tetrachloropropene	10436392						E	
	18611433							
	20589859							
	15022227							
	16500917							
Tetrachlorotoluene	29733708						*	
n-Tetracosane	646311							
n-Tetradecane	629594	E						
Tetradecanoic acid	544638				M			
Tetradecanol	27196005				M			
Tetradecene	26952136				M			

	Chemical Abstracts Reg. Nos.	MEDIA AND LAKE BASIN						
		WATER	SEDIMENT	AIR	DISCHARGES +SLUDGE	BENTHOS PLANKTON	FISH	WILDLIFE
Tetrahydrofuran	109999	EM						
Tetrahydropyran	142887	M						
Tetrathiohexane	58510137				M			
Trans-stilbene oxide	525064				M			
Tribromoanisole								
Trichloroaniline	54686918				M			
Trichloroanisole	87401						M	
Trichlorodimethoxy-phenol					M			
Trichlorodiene resin acids					M			
Trichloroethane	71556	M						
	79005							
Trichloroethylene	79016	EM			D			
Trichlorofluoromethane	75694	ME						
Trichloroguaiacol	26378187				SM			
(2,4,5-Trichloro-phenoxy) acetic acid			EDH	HD				
Trichloropropane	25735299				D			
Trichlorotrifluoro ethane	359295	M						
3,4,5-Trichlorovera-trole	16766293				S			
Trifluralin	1582098							
Trimethyl bicyclo 3.1.1 heptene	34389781				S			
	80568							
Trimethylisocyanurate	877894				M			
Triphenyl phosphate			M		M		M	
Trithiapentane	34202589				M			
Vanillin	121335				M			
Vanilone	579237				S			
Vinyl bromide	593602				D			
Vinyl chloride	75014				D			
Xylenes	1330207	ME			DM			
Zytron	299854				D			
Heavy Metals								
Cobalt	7440484	ESM	EHSM		E	M	HS	
Silver	7440224	EDHSM	SM			M	HS	
Strontium	7440246	M	EHS			M	HS	
Vanadium	7440622	M	HSM	M		M	HS	

*Sample identified only as "Great Lakes fish"

1 LAKE ERIE BASIN

The Lake Erie Basin for the purposes of this report consists of the lake itself and the tributaries entering the lake with the exception of the Detroit River. Because of the vast amount of data, the Detroit River, Lake St. Clair and St. Clair River will be considered together as one entity (Chapter 2), rather than being included with either Lake Erie or Lake Huron.

There are many sources of information on past and current biological, physical and chemical data for the Lake Erie Basin. For example, a 1976 report by the Ontario Ministry of Natural Resources (1) outlines 18 different existing long term Canadian and U.S. environmental programs in the Lake Erie Basin. Within the report, the sponsoring agencies are listed, the program objectives are described, and information is given on parameters measured, sampling frequency, and the availability of data from the programs. The results of many of the above programs are generally reported within the annual reports of the Surveillance Subcommittee of the IJC's Great Lakes Water Quality Board. Also information on point source discharges is contained within the annual reports of the Board's Remedial Programs Subcommittee. Copies of the Subcommittees' reports are available from the IJC Regional Office, Windsor, Ontario.

There are other reports which contain significant amounts of data on the Lake Erie Basin. These reports, for example, include: the Report to the IJC on the Pollution of Lake Erie (2); the Proceedings of a Conference in the Matter of Pollution of the Navigable Waters of the Detroit River and Lake Erie and Their Tributaries in the State of Michigan (3). Although these reports contain some information on organic contaminants and heavy metals, data on nutrient levels and the effects of eutrophication are primarily emphasized. Subsequent to the discovery of mercury discharges to the St. Clair River system in 1970, detailed studies were initiated to investigate the occurence of mercury and other heavy metals in Lake Erie fish, sediments and water. Also, in the early 1970's, investigations were initiated to determine the distribution within the aquatic ecosystem of pesticides and chlorinated hydrocarbons such as PCBs. Most of the information within this report is therefore obtained from the published and unpublished data from investigations initiated after 1970. An intensive nearshore surveillance program of the U.S. shoreline was initiated in 1978, however the details and the interpretation of the data will not be published until 1979.

1.1 DATA ON WATER QUALITY IN THE LAKE ERIE BASIN

Table 1.1-1 reviews the heavy metal concentrations found in the open waters and the nearshore areas of Lake Erie (references 4-9). The average distribution of total mercury in the bottom and surface waters found in Lake Erie during 1970-71 is shown in Fig. 1.1-1 and 1.1-2 (4). The average total mercury concentration of 0.17 ppb in Lake Erie was similar to values of 0.17 ppb and 0.18 ppb observed for lakes Huron and Superior respectively (4). The investigators found that the waters of the Western Basin had higher levels of mercury. In 1978, the Pollution from Land Use Activities Reference Group (9) reported concentrations of several trace elements in the open waters of Lake Erie which are shown in Table 1.1-1.

Nearshore studies of heavy metal concentrations were particularly emphasized in Port Colborne (Table 1.1-1 and Ashtabula Harbor (Tables 1.1-2 and 1.1-4). The ranges of heavy metal concentrations in tributaries to Lake Erie shown in Table 1.1-5 were obtained from the Michigan Department of Natural Resources (8). The averaged heavy metal concentrations in the Grand River and the Maumee River (Table 1.1-5) were obtained from the summaries of watershed studies sponsored by the Pollution from Land Use Activities Reference Group (10, 11). Detailed reports on the watershed studies will be available in late 1978.

Generally, concentrations of chlorinated pesticides and PCBs in the waters of Lake Erie and most of its tributaries have been below detection limits, as illustrated in Tables 1.1-3, 1.1-6 and 1.1-7 (references 6, 8, 15, 16, 17). In 1972 however, Glooschenko, Strachan and Sampson reported an average of 0.027 ppb PCBs in the surface waters of Lake Erie (12). Also, a 1973 study of the Cuyahoga River indicated Aroclor 1254 concentrations between .04 ppb and 0.59 ppb [Table 1.1-8 (reference 13)].

In the past few years, efforts have intensified to identify and quantify compounds, in addition to pesticides and PCBs, which may be present in Lake Erie waters. In an attempt to identify the components of chloroform extracts from Lake Erie waters, Strachan (14) identified phthalate esters in concentrations from 0.7 - 6 ppb, in addition to various quantities of fatty acids and hydrocarbons (Table 1.1-6). Analyses of various U.S. water supply systems located in the Lake Erie Basin, have shown the presence of phthalate esters, (8, 18) chlorinated methanes and benzene compounds (17, 18, 19) and a variety of other compounds (Tables 1.1-6, 1.1-7 and 1.1-9). Recently Fox (20), reported pentachlorophenol levels in Lake Erie from < 5 ppt to 1.7 ppb. Furthermore, the EPA study to identify previously unrecognized pollutants (18) revealed a large number of organic compounds at ppb levels in tributaries to Lake Erie (Table 1.1-7).

In 1978 the results of a study to determine PAH levels in selected U.S. drinking waters and their raw water sources, were published (164). Table 1.1-10 shows the values which were observed in the raw water source (Lake Erie) and in the drinking water of Buffalo, New York. For the purposes of comparison, the table also gives the observed concentrations of PAHs at the Syracuse Water System (uncontaminated water source - Lake Skaneateles) in New York and at Pittsburg, Pennsylvania where the water source - the Monongahela River - is contaminated with coke oven effluent.

Streamwaters leaving eleven agricultural watersheds in Southern Ontario were analyzed for a variety of pesticide during a PLUARG Task C study (170). Three of the 11 major watersheds were located in the Lake Erie Basin (Table 1.1-11). Tables 1.1-12 to 1.1-21 show the results of analyses for pesticides in the Lake Erie watersheds which are identified as AG-2 (Big Creek), AG-4 (Grand River) and AG-13 (Hillman Creek). The frequencies of occurrence of pesticides in all 11 watersheds are summarized in Table 1.1-22. Another PLUARG study (171) evaluated the concentrations of various organochlorine compounds in the waters of the Grand River. The concentrations are shown in Table 1.1-23.

Table 1.1-24 shows the concentrations of Freon 11, Freon 12, carbon tetrachloride and trichlorethylene which were detected in the open waters of Lake Erie (175). Distribution profiles of the compounds in Lake Erie waters will be published by the investigator at a later date.

TABLE 1.1-1

HEAVY METALS IN LAKE ERIE WATERS

SAMPLING STATION AND DATE	HEAVY METALS AND CONCENTRATIONS (µg/L)		INFORMATION SOURCE
Lake Erie 1970-71	Hg 0.17 ± 0.11 ppb (0-0.4) (See Distribution - Figure 1.1-1)		4
Western Lake Erie - 6 locations, 1973-75 filtered water unfiltered water	 Se 1-6 Se 9-48		5
Astabula Harbor - 1973	See Tables 1.1-2, 1.1-4		6
Port Colborne - discharge area of Algoma & Inco effluents August 1973	Cu 11-17 Pb 11-33 Co 7-8 Fe 150-180 Ni 140-320		7
- Nickel Beach Area	Cu 4-20 Pb 6-38 Co 4-15 Fe 30-450 Ni 4-840		7
- Welland Canal	Cu 6-17 Pb 6 Co 4-5 Fe 70-100 Ni 5-10		7
City of Monroe WTP Water Intake - Lake Erie 1973-77	Ni <5-14 Hg <.1-.8 Pb <1-8 Zn 11-24 Cd <.1-.2	Cu 3-45[b] Ag <1-2 Se <2 As <1-.2 Cr <1-2[a]	8
Open waters 1976-77	Hg ≤0.5 Pb ≤1-3 Cd ≤.2	Cu 1.0-2.5 Zn 2.0-9.0 As 0.3-0.6	9

(a) "total" unless otherwise specified

(b) "dissolved" metal concentration

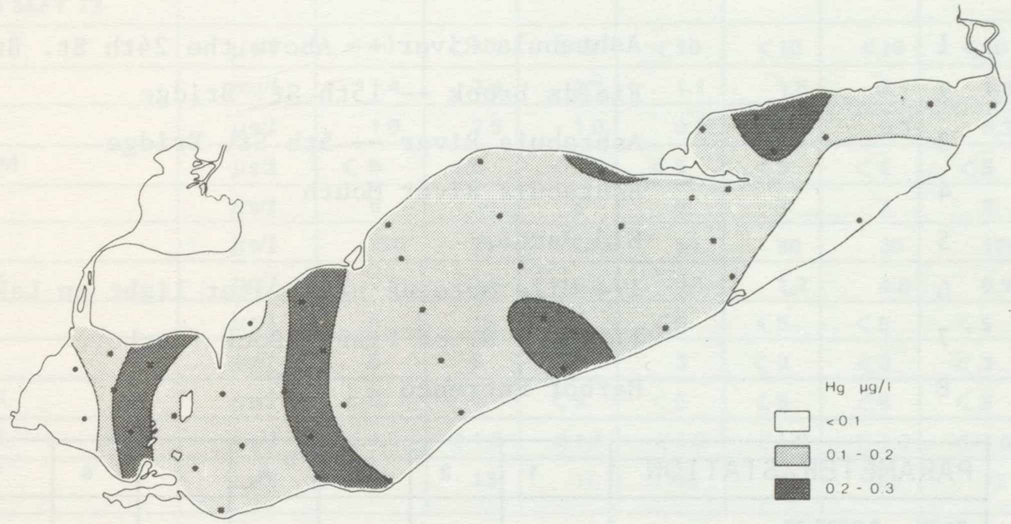

Fig 1.1-1 The average distribution of total mercury in the surface waters of Lake Erie (1970-1971). Dots represent sampling stations.

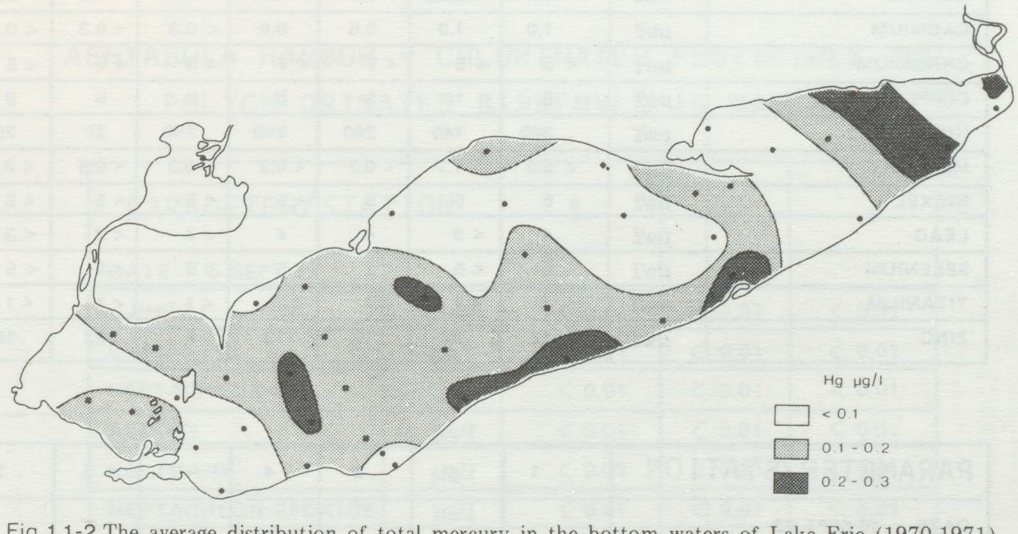

Fig 1.1-2 The average distribution of total mercury in the bottom waters of Lake Erie (1970-1971). Dots represent sampling stations.

TABLE 1.1-2

METAL CONCENTRATIONS DETERMINED IN THE 1973
"WATER POLLUTION INVESTIGATION: ASHTABULA HARBOR" (6)

STATION	LOCATION
1	Ashtabula River -- Above the 24th St. Bridge
2	Fields Brook -- 15th St. Bridge
3	Ashtabula River -- 5th St. Bridge
4	Ashtabula River Mouth
5	Mid Harbor
6	1/4 Mile outside breakwater light on Lake Erie
7	1/8 Mile N. of Pinney Dock (Harbor)
8	Harbor Entrance

PARAMETER/STATION		1	2	3	4	5	6	7
DATE 8 SEPT 73								
ARSENIC	μg/l	< 10	< 10	< 10	< 10	< 10	< 10	< 10
BARIUM	mg/l	1.5	2.5	2.0	1.5	1.5	1.0	1.0
CADMIUM	μg/l	1.0	1.0	0.6	0.6	< 0.3	< 0.3	< 0.3
CHROMIUM	μg/l	< 5	< 5	< 5	< 5	< 5	< 5	< 5
COPPER	μg/l	6	10	8	8	8	8	8
IRON	μg/l	360	140	260	240	280	20	70
MERCURY	μg/l	< 0.3	1.3	< 0.3	< 0.3	< 0.3	< 0.5	< 0.5
NICKEL	μg/l	< 5	5	< 5	< 5	< 5	< 5	< 5
LEAD	μg/l	4	< 3	4	4	< 3	< 3	< 3
SELENIUM	μg/l	< 5	< 5	< 5	< 5	< 5	< 5	< 5
TITANIUM	mg/l	< 1	< 1	< 1	< 1	< 1	< 1	< 1
ZINC	μg/l	12	22	10	10	8	22	16

PARAMETER/STATION		1	2	3	4	5	6	7
DATE 10 SEPT 73								
ARSENIC	μg/l	< 10	< 10	< 10	< 10	< 10	< 10	< 10
BARIUM	mg/l	< 1.0	3.5	2.0	1.0	1.5	1.0	1.0
CADMIUM	μg/l	< 0.3	0.5	0.5	0.5	< 0.3	< 0.3	< 0.3
CHROMIUM	μg/l	< 5	< 5	< 5	< 5	< 5	< 5	< 5
COPPER	μg/l	10	10	9	8	9	8	8
IRON	μg/l	360	110	180	80	90	30	60
MERCURY	μg/l	4.3	1.3	< 0.3	0.4	< 0.3	< 0.3	< 0.3
NICKEL	μg/l	< 5	< 5	< 5	< 5	< 5	< 5	< 5
LEAD	μg/l	< 3	< 3	< 3	< 3	< 3	< 3	< 3
SELENIUM	μg/l	< 5	< 5	< 5	< 5	< 5	< 5	< 5
TITANIUM	mg/l	< 1	< 1	< 1	< 1	< 1	< 1	< 1
ZINC	μg/l	6	10	9	7	5	5	7

TABLE 1.1-2 CONT'D

PARAMETER / STATION		1	2	3	4	5	6	7	8
DATE 5 SEPT 73									
ARSENIC	μg/ℓ	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
BARIUM	mg/ℓ	1.4	2.9	2.1	1.1	1.5	1.1	1.0	1.1
CADMIUM	μg/ℓ	1.0	2.5	1.0	0.3	0.3	0.3	0.3	0.3
CHROMIUM	μg/ℓ	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
COPPER	μg/ℓ	6	10	8	9	7	7	8	8
IRON	μg/ℓ	260	250	60	60	80	30	120	40
MERCURY	μg/ℓ	0.6	1.4	0.6	0.6	1.2	4.8	0.9	1.4
NICKEL	μg/ℓ	5	15	< 5	< 5	< 5	< 5	< 5	< 5
LEAD	μg/ℓ	5	5	5	3	< 3	< 3	< 3	5
SELENIUM	μg/ℓ	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
TITANIUM	mg/ℓ	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
ZINC	μg/ℓ	16	13	17	15	12	22	12	22

TABLE 1.1-3

ASHTABULA HARBOR - CHLORINATED PESTICIDES AND POLYCHLORINATED BIPHENYLS IN WATER

PARAMETER/STATION		2	5	6
DATE 5 SEPT 73				
α-BHC	μg/ℓ	< 0.01	< 0.01	< 0.01
LINDANE	μg/ℓ	< 0.01	< 0.01	< 0.01
HEPTACHLOR	μg/ℓ	< 0.01	< 0.01	< 0.01
ALDRIN	μg/ℓ	< 0.01	< 0.01	< 0.01
KELTHANE	μg/ℓ	< 0.01	< 0.01	< 0.01
HEPTACHLOR EPOXIDE	μg/ℓ	< 0.01	< 0.01	< 0.01
γ-CHLORDANE	μg/ℓ	< 0.01	< 0.01	< 0.01
ENDOSULFAN I	μg/ℓ	< 0.01	< 0.01	< 0.01
p,p'-DDE	μg/ℓ	< 0.01	< 0.01	< 0.01
DIELDRIN	μg/ℓ	< 0.01	< 0.01	< 0.01
ENDRIN	μg/ℓ	< 0.01	< 0.01	< 0.01
o,p'-DDT	μg/ℓ	< 0.01	< 0.01	< 0.01
ENDOSULFAN II	μg/ℓ	< 0.01	< 0.01	< 0.01
p,p'-DDD	μg/ℓ	< 0.01	< 0.01	< 0.01
,p,'-DDT	μg/ℓ	< 0.01	< 0.01	< 0.01
METHOXYCHLOR	μg/ℓ	< 0.01	< 0.01	< 0.01
PCB's	μg/ℓ	< 0.1	< 0.1	< 0.1

TABLE 1.1-4

ASHTABULA HARBOR

MERCURY DATA (µG/L)[1]

STATION	4/11/73	6/25	7/31	9/5	9/8	9/10	12/10	5/8/74	5/8	5/9	5/9	5/10
UPSTREAM – PC BRIDGE	–	–	–	0.6	< 0.3	4.3	–	< 0.5	< 0.5	< 0.5	< 0.5	–
ASHTABULA RIVER – E. 24th ST.	0.4*	0.3*	0.2*	–	–	–	2.2(*,4)	0.4	< 0.5	< 0.5	< 0.5	–
FIELDS BROOK – STATE RD.(2)	–	–	–	–	–	–	–	–	–	–	–	21
FIELDS BROOK – STATE RD.(3)	–	–	–	–	–	–	–	–	–	–	–	1.9
FIELDS BROOK – RT. 20	0.2*	0.8*	0.3*	–	–	–	–	–	–	–	–	–
FIELDS BROOK – E. 15th ST.	0.8*	0.5*	0.4*	1.4	1.3	1.3	–	1.4	2.0	4.2	2.9	5.8
FIELDS BROOK MOUTH	–	–	–	–	–	–	–	1.5	2.0	4.6	3.7	–
ASHTABULA RIVER – E. 6th ST.	0.2*	0.6*	0.2*	0.6	< 0.3	< 0.3	–	0.8	< 0.5	< 0.7	< 0.5	–
ASHTABULA RIVER (MILEPOINT 0.0)	–	–	–	0.6	< 0.3	0.4	–	–	–	–	–	–
ASHTABULA MID HARBOR	–	–	–	1.2	< 0.3	< 0.3	–	–	–	–	–	–
HARBOR ENTRANCE	–	–	–	1.4	–	–	–	–	–	–	–	–
OFFSHORE	–	–	–	4.8	< 0.5	< 0.3	–	–	–	–	–	–
PINNEY DOCK	–	–	–	0.9	< 0.5	< 0.3	–	–	–	–	–	–

* USEPA DATA (PERSONAL COMMUNICATION WINKLHOFER TO ZAR, JAN. 28, 1974)

(1) – OHIO WATER QUALITY STANDARD FOR MERCURY 12/18/73 0.5 µg/ℓ

(2) – EAST SIDE OF STATE RD. BRIDGE OVER FIELDS BROOK (UPSTREAM)

(3) – WEST SIDE OF STATE RD. BRIDGE OVER FIELDS BROOK (OUTFALL SAMPLE)

(4) – SAMPLE FROM OUTFALL ON E. 24th ST. KNOWN TO THE USEPA TO CONTAIN DISCHARGES FROM ASHTABULA GENERAL HOSPITAL AND A SANITARY BYPASS.

TABLE 1.1-5

HEAVY METAL CONCENTRATIONS IN WATERS OF TRIBUTARIES TO LAKE ERIE

($\mu g/\ell$)[a]

Date	Stations	No. Samples	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn	Information Source
1973-77	Huron River Superior TWP.	7	1-2	.2-2			4-9[(b)]	3-28	<.2-.5		22	<2	<1-2[(b)]		9-30	8
1970-77	Huron River Flat Rock WTP (intake)	12	1	<.1-.3	4-11		6-10	4-14	<.1-3.1		11-46	<2	<1		48-250	8
1973-77	Huron River (near mouth) Berlin TWP	5	2-3[(b)]	.3-2			4-8[(b)]	2-33	<.2-.4		24	<2	<1-2		26-36	8
1973-77	River Raisin City of Dundee WTP	10	<1-3[(b)]	<.1-4	6-16		4-220[(b)]	<1-24	<.1-9.0		21-29	<2	<1-2[(b)]		6-550[(b)]	8
1973-77	River Raisin (near mouth)	7	2-3	.2-2			14-16	<1-31	<.2		22-24	<2	<1-4[(b)]		20-30[(b)]	8
1976	Grand River[(c)] Watershed outlet						10	5							32	10
1975-77	Maumee River Basin Streamwater Background			11	3	10	3	20			82				21	11
	Groundwater			9	98	80	250	94							954	

(a) "total" unless otherwise specified

(b) dissolved fraction

(c) flow weighted mean concentrations

TABLE 1.1-6

ORGANIC CONTAMINANTS DETECTED
IN LAKE ERIE WATERS

SAMPLING STATION AND DATE	ORGANIC CONTAMINANTS AND CONCENTRATIONS	(μg/L)	INFORMATION SOURCE
Lakewide mean - 1972	PCBs	0.027	12
Presque Isle Bay and 2 stations in immediate vicinity 04/72-12/72 (27 sampling periods)	DDT Lindane Aldrin Dieldrin Heptachlor	<.04 <.002 <.004 <.006 <.004	15
Lakewide - 1973	Phthalate esters Fatty acids Hydrocarbons	.7-6 .2-3 .3-4	14
Astabula Harbor	Chlorinated pesticides and PCBs (See Table 1.1-3)		6
Erie, PA 09/74 10/75	PCB	<.02	16
City of Monroe WTP 1975-76	DEHP (01/76) Not detected: DBP, toxaphene, chlordane, 2,4-D, silvex, endrin, heptachlor, lindane, methoxychlor, PCBs	2.6	8
Erie, PA Water Supply - 1976	Chloroform Dibromochloromethane Methylene chloride (Also See Table 1.1-9)	18 10 1.8	17
Buffalo, N. Y. Lake Erie 06/76	Benzene Butyl Phthalyl Butyl Glycolate Dichloromethane Methyl-2-Ethyl Hexanoate Methyl Palmitate	1 2 5 trace 2	18

TABLE 1.1-6 CONT'D

ORGANIC CONTAMINANTS DETECTED IN LAKE ERIE WATERS

SAMPLING STATION AND DATE	ORGANIC CONTAMINANTS AND CONCENTRATIONS	(µg/L)	INFORMATION SOURCE
City of Cleveland Water Supply - 1977 (no concentrations determined)	m-xylene o-xylene p-xylene m-dichlorobenzene p-dichlorobenzene 2,5-dimethyldecane 2,6-dimethylundecane n-tetradecane n-hexadecane n-decylcyclohexane 10-methyleicosane styrene bis-(2-chloroisopropyl) ether		19
Lake Erie - Mouth Detroit River - 1977	Pentachlorophenol	1.7	20
Point Pelee - 1977	Pentachlorophenol	<.005	
Mouth - Grand River - 1977	Pentachlorophenol	.067	
Western Basin - 1977	Pentachlorophenol	.005	
Eastern and Central Basin - 1977-78	Trichlorofluoromethane (Freon 11) Dichlorodifluoromethane (Freon 12) Carbon Tetrachloride Trichloroethylene (See Table 1.1-24 for concentrations)		175

TABLE 1.1-7

WATER ANALYSES OF TRIBUTARIES ENTERING LAKE ERIE

SAMPLING STATION AND DATE	ORGANIC COMPOUNDS AND CONCENTRATIONS	(µg/L)	INFORMATION SOURCE
Fields Brook, Ashtabula, Ohio, 1976	Camphor (IS)[(a)]	–	18
	Chloroform	9	
	$C_xH_yCl_z$, $x \geq 4$, $z \geq 5$	6	
	$C_xH_yCl_z$, $x \geq 4$, $z \geq 5$	7	
	$C_xH_yCl_z$, $x \geq 4$, $z \geq 5$	99	
	$C_xH_yCl_z$, $x \geq 4$, $z \geq 5$	100	
	$C_xH_yCl_z$, $x \geq 4$, $z \geq 5$	14	
	$C_xH_yCl_z$, $x \geq 4$, $z \geq 5$	3	
	$C_xH_yCl_z$, $x \geq 4$, $z \geq 5$	13	
	Dichlorobenzene	2	
	1, 2-Dichloroethane	4	
	Diethyl Hexyl Phthalate	2	
	Hexachlorobenzene	4	
	Hexachlorobutadiene	22	
	Hexachlorobutene	21	
	Hexachloroethane	3	
	Methyl-2-Ethyl Hexanoate (IS)[(a)]	–	
	Methyl Palmitate	3	
	Methyl Stearate	2	
	Methyl-t-Butyl Ketone	1	
	Pentachlorobutadiene	38	
	Pentachlorobutene	64	
	Pentachloroethane	2	
	Tetrachlorobutadiene	11	
	Tetrachloroethane	44	
	1, 1, 2, 2-Tetrachloroethane	1	
	Tetrachloroethylene	45	
	Tetrahydrofuran	318	
	Trichloroethylene	188	

TABLE 1.1-8

RESULTS - CUYAHOGA RIVER PCB STUDY*

CUYAHOGA RIVER PCB LOADING

SAMPLE DATE	(Distance from Lake Erie) MILE POINT	Aroclor 1254 Ng/Liter	FLOW MGD	Aroclor 1254 Gms/Day
5/2/73	11.9	105	860	342
5/2/73	21.5	86	730	237
5/2/73	37.1	55	547	116
5/2/73	39.7	129	522	255
5/2/73	44.6	325	502	613
5/2/73	46.9	51	470	90
5/2/73	51.7	589	438	976
5/2/73	59.0	51	395	76
5/2/73	65.1	39	364	53
5/2/73	76.9	61	301	69

PCB TRIBUTARY LOADINGS TO CUYAHOGA RIVER

SAMPLE POINT	SAMPLE DATE	MILE POINT	Aroclor 1254 Ng/Liter	FLOW MGD	Aroclor 1254 Gms/Day
Big Creek	5/17/73	7.2	238	16	15
Mill Creek	5/17/73	11.7	187	19	13
Tinkers Creek	5/17/73	17.2	482	78	141
Brandywine Creek	5/17/73	25.2	180	18	12
Furnace Run	5/16/73	34.5	48	12	2
Mud Brook	5/16/73	41.7	86	15	5
Little Cuyahoga	5/16/73	44.2	140	89	47
Breakneck Creek	5/16/73	58.8	57	76	16

MAJOR PCB POINT SOURCE IDENTIFICATION
IN CUYAHOGA RIVER

SOURCE	% OF TOTAL PCB LOADING TO CUYAHOGA RIVER
Southerly Sewage Treatment Plant	55
Republic Steel	28.2
Combined sewer overflow #168-L-CR Harshaw	10

*CUYAHOGA RIVER POLYCHLORINATED BIPHENYLS STUDY 1973, A.S. Gedeon, U.S. EPA, Region V, Surveillance and Analysis Division, Ohio District Office. December 1973.

TABLE 1.1-9

NATIONAL ORGANIC MONITORING SURVEY (17)
Finished Water Analyses Data, Phase One

City: Erie, Pennsylvania — March 1, thru April 3, 1976

Parameter	µg/ℓ	Detection Limit (µg/ℓ)
carbon tetrachloride	ND	2
chloroform	18	
1,2-dichloroethane	ND	2
dibromochloromethane	10	
bromoform	ND	3
benzene	ND	2
p-dichlorobenzene	ND	1
methylene chloride	1.8	
1,2,4-trichlorobenzene	ND	1
bis (2-chloroethyl) ether	ND	5
1,1,2-trichloroethylene	ND	3
2,4-dichlorophenol	ND	.01
fluoranthene	ND	.01
11,12-benzfluoranthene	A	
3,4-benzfluoranthene	ND	.03
1,12-benzperylene	ND	.05
3,4-benzpyrene	ND	.03
indeno (1,2,3-cd) pyrene	ND	.05
bromodichloromethane	ND	2
polychlorinated biphenyls (PCBs)	ND	.12
pentachlorophenol	ND	.01

ND - not detected
A - Analysis not attempted

TABLE 1.1-10

RESULTS OF ANALYSES FOR PAHS IN
RAW AND FINISHED WATERS AT 3 LOCATIONS

	LOCATION - SAMPLE					
PAH conc. ng/L	Buffalo, N.Y		Syracuse, N.Y.*		Pittsburgh, Pa*	
	raw	finished	raw	finished	raw	finished
Fluoranthene	ND	ND		ND	407	ND
Benzo(j)fluoranthene	ND	ND		ND	35.7	0.3
Benzo(k)fluoranthene	0.6	ND		0.4	19.1	0.2
Benzo(a)pyrene	0.3	0.2		0.3	42.1	0.4
Indeno(1,2,3-cd)pyrene	ND	ND		ND	60.4	1.2
Benzo(ghi)perylene	3.8	0.7		0.4	34.4	0.7

(1) Treatment consists of: coagulation, activated carbon addition, chlorination, and fluoridation.

(2) Treatment consists of: copper sulfate addition, chlorination, and fluoridation.

(3) Treatment consists of: lime, ferric sulfate addition, activated carbon addition, chlorination and fluoridation.

*Not in Lake Erie Basin. Results included for purposes of comparison.

Table 1.1-11 Size of Major and Minor Watersheds

PLUARG Task C Study - Pesticides in Streamwaters

Great Lakes	Major Watershed Name	Size (km^2)	AG-	Minor Watershed Name	Size(km^2)	Distance from Lake (km) [a]
Lake Huron	Ausable River	1562	3	Little Ausable River	62	121
	Maitland River	2686	6	Trib. of Upper Maitland River	55	110
	Saugeen River	3972	14	Mill Creek	45	36.7
Lake St. Clair	Thames River	5882	1	Big Creek	51	16.7
			5	Holiday Creek	30	253
Lake Erie	Big Creek	742	2	Venison Creek	79	19.6
	Grand River	6671	4	Canagagigue Creek	19	214
	Hillman Creek	162	13	Hillman Creek	20	7.4
Lake Ontario	Humber River	317	11	Salt Creek	24	34.9
	Shelter Valley Creek	944	7	Shelter Valley Creek	57	7.7
	Twenty Mile Creek	280	10	North Creek	30	26.5

[a] Distance from flow gauging station and water sampling site to river mouth

Table 1.1-12 The frequency and concentration of ΣDDT found in stream water between May 1975 and April 1977 in 11 agricultural watersheds

Watershed	Period May-Apr.	Analysis (#)	ΣDDT - Frequency and Content in Stream Water (ng/L) Not Det. (<0.4)	Trace (0.4-0.9)	Low (1.0-10.0)	Medium (11-100)	High (100+)	Mean	Range	SD
AG-1	1975-76	61	5	0	42	14	0	6.7	ND-39	14.
	1976-77	58	4	2	49	3	0	3.1	ND-14	7.3
AG-2	1975-76	29	1	0	21	5	2	21.	ND-347	139.
	1976-77	34	1	2	21	8	2	17.	ND-158	76.
AG-3	1975-76	52	5	1	39	7	0	3.9	ND-46	17.
	1976-77	57	4	5	43	4	1	7.1	ND-114	34.
AG-4	1975-76	34	5	0	26	3	0	3.8	ND-14	8.2
	1976-77	43	2	3	33	5	0	6.5	ND-97	29.
AG-5	1975-76	55	4	0	46	5	0	4.0	ND-17	7.7
	1976-77	56	4	5	38	8	1	11.	ND-261	72.
AG-6	1975-76	58	3	1	45	9	0	5.3	ND-55	16.
	1976-77	41	3	3	29	6	0	4.5	ND-23	11.
AG-7	1975-76	28	2	0	20	5	1	10.	ND-120	45.
	1976-77	19	1	2	13	3	0	3.5	ND-13	8.7
AG-10	1975-76	24	2	0	21	1	0	3.9	ND-13	6.4
	1976-77	37	2	1	28	5	1	8.9	ND-126	42.
AG-11	1975-76	18	0	0	15	3	0	5.6	1.0-17	9.2
	1976-77	5	0	1	3	1	0	4.7	0.7-12	12.
AG-13	1975-76	62	2	0	48	12	0	7.9	ND-59	17.
	1976-77	87	5	7	61	12	2	9.6	ND-211	54.
AG-14	1975-76	48	6	0	35	7	0	5.3	ND-27	12.
	1976-77	43	4	1	31	7	0	4.9	ND-24	11.
TOTAL:	1975-76	469	35	2	358	71	3	6.7	ND-347	38.
	1976-77	480	30	32	349	62	7	7.7	ND-211	15.
GRAND TOTAL:	1975-77	949	65	34	707	133	10	7.1	ND-347	28.

Table 1.1-13 The frequency and concentration of dieldrin in water collected from 11 agricultural watersheds between May 1975 and April 1977

Watershed	Period May-Apr.	Analysis (#)	Frequency and Content in Stream Water (ng/L) Not Det. (<0.4)	Trace (0.4-0.9)	Low (1.0-10.0)	Medium (11-100)	High (100+)	Mean	Range	SD
AG-1	1975-76	61	41	10	8	2	0	1.5	ND-32	11.
	1976-77	54	43	4	7	0	0	0.5	ND-4	1.6
AG-2	1975-76	29	19	3	6	1	0	2.7	ND-63	23.
	1976-77	34	29	1	4	0	0	0.5	ND-5	1.9
AG-3	1975-76	52	49	2	1	0	0	<0.4	ND-4	-
	1976-77	61	59	2	0	0	0	<0.4	ND-0.9	-
AG-4	1975-76	34	34	0	0	0	0	<0.4	ND	-
	1976-77	43	42	1	0	0	0	<0.4	ND-0.9	-
AG-5	1975-76	55	49	2	4	0	0	<0.4	ND-1.	-
	1976-77	56	54	0	2	0	0	<0.4	ND-5	-
AG-6	1975-76	58	54	2	2	0	0	<0.4	ND-4	-
	1976-77	41	39	0	2	0	0	<0.4	ND-4	-
AG-7	1975-76	28	24	1	3	0	0	0.6	ND-9	3.4
	1976-77	19	18	0	1	0	0	<0.4	ND-1.	-
AG-10	1975-76	24	22	2	0	0	0	<0.4	ND-0.9	-
	1976-77	37	34	1	0	2	0	2.7	ND-82	27.
AG-11	1975-76	18	18	0	0	0	0	<0.4	ND	-
	1976-77	5	5	0	0	0	0	<0.4	ND	-
AG-13	1975-76	62	16	3	28	14	1	8.0	ND-120	31.
	1976-77	87	18	2	43	24	0	6.8	ND-33	14.
AG-14	1975-76	48	45	2	1	0	0	<0.4	ND-1.	-
	1976-77	43	41	1	1	0	0	<0.4	ND-1.	-
TOTAL	1975-76	469	371	27	53	17	1	1.6	ND-120	14.
	1976-77	480	382	12	60	26	0	1.7	ND-82	11.
GRAND TOTAL:	1975-77	949	753	39	113	43	1	1.6	ND-120	12.

Table 1.1-14 Frequency & concentration of chlordane and heptachlor epoxide in water collected from 11 agricultural watersheds between May 1975 and April 1977

Watershed	Period May-Apr.	Analysis (#)	Frequency & concentration in Stream Water (ng/L) Not Det.	Trace (<0.9)	Low (1.0-10)	Medium (11-100)	High (100+)	Mean	Range	SD
Chlordane										
AG-1	1975-77	115	114	0	1	0	0	<0.4	ND-4	-
AG-2	"	63	62	0	1	0	0	<0.4	ND-4	-
AG-3	"	113	111	0	1	1	0	<0.4	ND-11	-
AG-4	"	77	76	0	1	0	0	<0.4	ND-4	-
AG-5	"	111	107	0	3	1	0	<0.4	ND-47	9.0
AG-6	"	99	98	0	1	0	0	<0.4	ND-4	-
AG-7	"	47	47	0	0	0	0	ND	ND	-
AG-10	"	61	60	0	1	0	0	<0.4	ND-4	-
AG-11	"	23	23	0	0	0	0	ND	ND	-
AG-13	"	149	146	0	3	0	0	<0.4	ND-10	-
AG-14	"	91	90	0	1	0	0	<0.4	ND-4	-
TOTAL	1975-77	949	934	0	13	2	0	<0.4	ND-47	-
Heptachlor Epoxide										
AG-1	1975-77	115	108	3	4	0	0	<0.4	ND-2	-
AG-2	"	63	59	2	1	1	0	<0.4	ND-23	-
AG-3	"	113	111	2	0	0	0	<0.4	ND-0.7	-
AG-4	"	77	77	0	0	0	0	ND	ND	-
AG-5	"	111	107	0	3	1	0	<0.4	ND-15	-
AG-6	"	99	99	0	0	0	0	ND	ND	-
AG-7	"	47	47	0	0	0	0	ND	ND	-
AG-10	"	61	59	1	1	0	0	<0.4	ND-2	-
AG-11	"	23	22	0	1	0	0	<0.4	ND-1	-
AG-13	1975-76	62	55	0	3	3	1	7.6	ND-370	94
	1976-77	87	57	1	20	9	0	2.9	ND-25	12
AG-14	1975-77	91	91	0	0	0	0	ND	ND	-
TOTAL	1975-77	949	892	9	33	14	1	0.8	ND-370	24

Table 1.1-15 Frequency and concentration of chlorophenoxy and chlorobenzoic acid herbicides in water collected from 11 agricultural watersheds between May 1975 and April 1977

Watershed	Period (May-Apr)	Analysis (#)	Not Det.	Frequency and content in water (ug/L) Low (0.1-1.0)	Medium (1.1-10.0)	High (10.1 +)	Mean	Range	SD
2,4-D									
AG-1	1975-76	61	52	6	2	1	0.3	ND-15.9	4.1
	1976-77	54	45	8	1	0	0.1	ND-3.9	1.1
AG-2	1975-76	29	28	1	0	0	<0.1	ND-0.3	-
	1976-77	34	30	3	1	0	<0.1	ND-1.1	-
AG-3	1975-76	52	46	6	0	0	<0.1	ND-0.7	-
	1976-77	61	60	1	0	0	<0.1	ND-0.3	-
AG-4	1975-76	34	31	3	0	0	<0.1	ND-0.8	-
	1976-77	43	41	2	0	0	<0.1	ND-0.8	-
AG-5	1975-76	55	50	5	0	0	<0.1	ND-0.3	-
	1976-77	56	54	2	0	0	<0.1	ND-0.3	-
AG-6	1975-76	58	54	4	0	0	<0.1	ND-0.8	-
	1976-77	41	39	0	2	0	<0.1	ND-2.1	-
AG-7	1975-76	28	26	2	0	0	<0.1	ND-0.3	-
	1976-77	19	17	2	0	0	<0.1	ND-0.4	-
AG-10	1975-76	24	23	1	0	0	<0.1	ND-0.3	-
	1976-77	37	37	0	0	0	ND	ND	-
AG-11	1975-77	23	23	0	0	0	ND	ND	-
AG-13	1975-76	62	55	6	0	1	5.2	ND-320.	81.
	1976-77	87	83	4	0	0	<0.1	ND-0.6	-
AG-14	1975-76	48	48	0	0	0	ND	ND	-
	1976-77	43	41	2	0	0	<0.1	ND-0.8	-
TOTAL	1975-76	469	431	34	2	2	0.7	ND-320.	29.
	1976-77	480	452	24	4	0	<0.1	ND-3.9	0.5
GRAND TOTAL	1975-77	949	883	58	6	2	0.4	ND-320.	20.

Watershed	Period (May-Apr)	Analysis (#)	Not Det.	Frequency and content in water (ug/L) Low (0.1-1.0)	Medium (1.1-10.0)	High (10.1 +)	Mean	Range	SD
2,4,5-T									
AG-1	1975-76	61	55	5	1	0	<0.1	ND-1.1	-
	1976-77	54	50	4	0	0	<0.1	ND-0.8	-
AG-3	1975-77	113	111	2	0	0	<0.1	ND-0.3	-
AG-4	1975-77	77	76	1	0	0	<0.1	ND-0.8	-
AG-7	1975-77	47	46	1	0	0	<0.1	ND-0.3	-
AG-10	1975-77	61	60	1	0	0	<0.1	ND-0.3	-
AG-13	1975-77	149	143	6	0	0	<0.1	ND-0.3	-
AG-2,5,6,11,14		387	387	0	0	0	ND	ND	-
TOTAL	1975-77	949	928	20	1	0	<0.1	ND-1.1	-
MCPA									
AG-4	1975-77	77	75	2	0	0	<0.1	ND-0.3	-
AG-6	1975-77	99	98	1	0	0	<0.1	ND-0.3	-
AG-13	1975-77	149	148	1	0	0	<0.1	ND-0.3	-
AG-14	1975-77	91	89	2	0	0	<0.1	ND-0.3	-
AG-1,2,3,5,7,10,11		533	533	0	0	0	ND	ND	-
TOTAL	1975-77	949	943	6	0	0	<0.1	ND-0.3	-
dicamba									
AG-13	1975-77	149	148	1	0	0	<0.1	ND-0.7	-
AG-1,2,3,4,5,6,7,10,11,14		800	800	0	0	0	ND	ND	-
TOTAL	1975-77	949	948	1	0	0	<0.1	ND-0.7	-

AG-13: One sample contained 320 ug/L and was associated with the spraying of the stream bank.

Table 1.1-16 Frequency and concentrations of total endosulfan in water collected from 11 agricultural watersheds between May 1975 and April 1977

Watershed	Period (May-Apr)	Analysis (#)	Frequency of ΣEndosulfan in water (ng/L) Not Det. (<0.4)	Trace (0.4-0.9)	Low (1.0-10.0)	Medium (11-100)	High (101+)	Mean	Range	SD
AG-1	1975-76	61	42	0	17	2	0	2.7	ND-41	12.3
	1976-77	54	45	2	7	0	0	0.5	ND-9	2.5
AG-2	1975-76	29	21	0	5	3	0	2.2	ND-17	9.6
	1976-77	34	30	0	3	1	0	1.0	ND-17	6.5
AG-3	1975-76	52	46	2	4	0	0	<0.4	ND-6	1.7
	1976-77	61	60	0	1	0	0	<0.4	ND-8	2.0
AG-4	1975-76	34	33	0	1	0	0	<0.4	ND-6	2.0
	1976-77	43	41	1	1	0	0	<0.4	ND-4	0.4
AG-5	1975-76	55	50	0	5	0	0	0.5	ND-6	2.6
	1976-77	56	54	1	1	0	0	<0.4	ND-6	1.6
AG-6	1975-76	58	51	0	5	0	2	5.5	ND-173	52.
	1976-77	41	39	1	1	0	0	<0.4	ND-2	0.6
AG-7	1975-76	28	27	0	0	0	1	4.8	ND-128	49.
	1976-77	19	19	0	0	0	0	ND	ND	-
AG-10	1975-76	24	22	0	2	0	0	<0.4	ND-4	1.6
	1976-77	37	35	0	2	0	0	<0.4	ND-3	1.1
AG-11	1975-76	18	17	0	1	0	0	<0.4	ND-4	2.1
	1976-77	5	5	0	0	0	0	ND	ND	-
AG-13	1975-76	62	22	1	9	30	0	16.	ND-100	38.
	1976-77	87	22	3	18	44	0	15.	ND-52	29.
AG-14	1975-76	48	44	1	2	1	0	0.5	ND-11	3.9
	1976-77	43	41	2	0	0	0	<0.4	ND-0.7	0.3
TOTAL	1975-76	469	375	4	51	36	3	3.7	ND-173	28.
	1976-77	480	391	10	34	45	0	2.9	ND-52	17.
GRAND TOTAL	1975-77	949	766	14	85	81	3	3.3	ND-173	23.

Table 1.1-17 Frequency and concentration of PCB in stream water collected from 11 agricultural watersheds between May 1975 and April 1977

Watershed	Period May-Apr.	Analysis (#)	Frequency and content in water (ng/L) Not Det. (<2)	Low (2-10)	Medium (11-100)	High (100+)	Mean	Range	SD
AG-1	1975-76	61	2	5	53	1	40	10-110	43
	1976-77	54	0	19	35	0	24	ND-60	31
AG-2	1975-76	29	0	2	27	0	46	4-100	53
	1976-77	34	2	6	25	1	30	ND-200	68
AG-3	1975-76	52	1	3	48	0	39	10-100	37
	1976-77	61	3	11	46	1	28	ND-200	57
AG-4	1975-76	34	2	6	26	0	36	ND-90	50
	1976-77	43	6	11	26	0	20	ND-50	32
AG-5	1975-76	55	1	6	48	0	40	ND-80	41
	1976-77	56	8	9	39	0	24	ND-100	41
AG-6	1975-76	58	3	8	47	0	35	ND-80	43
	1976-77	41	2	9	30	0	25	ND-60	31
AG-7	1975-76	28	0	1	27	0	41	10-100	45
	1976-77	19	1	3	15	0	22	ND-60	24
AG-10	1975-76	24	2	3	18	1	35	ND-110	23
	1976-77	37	5	7	25	0	23	ND-60	38
AG-11	1975-76	18	2	1	15	0	36	ND-100	50
	1976-77	5	0	1	4	0	24	10-40	62
AG-13	1975-76	62	2	6	54	0	39	10-100	38
	1976-77	87	5	20	61	1	24	ND-120	35
AG-14	1975-76	48	4	8	36	0	36	ND-100	49
	1976-77	43	2	9	32	0	23	ND-60	31
Total	1975-76	469	19	49	399	2	38	ND-110	43
	1976-77	480	34	105	338	3	25	ND-200	41
Grand Total:	1975-77	949	53	154	737	5	31	ND-200	42

Table 1.1-18 Frequency and concentrations of organophosphorus insecticides in water collected from 11 agricultural watersheds between May 1975 and April 1977

Watershed	Period May-Apr.	Analysis (#)	Frequency and content in water (ug/L) Not Det. (<0.01)	Low (0.01-0.10)	Medium (0.11-1.0)	High (1.1-10.0)	Very High (10+)	Mean	Range	SD
Chlorpyrifos										
AG-2	1975-77	63	62	0	1	0	0	<0.01	ND-0.15	-
AG-5	1975-77	111	110	0	0	1	0	0.01	ND-1.60	0.29
AG-13	1975-77	149	148	0	1	0	0	<0.01	ND-0.25	-
AG-1,3,4,6,7,10,11,14		626	626	0	0	0	0	ND	ND	-
Total	1975-77	949	946	0	2	1	0	<0.01	ND-1.60	-
Diazinon										
AG-2	1975-77	63	62	0	0	0	1	0.42	ND-25.	6.4
AG-3	1975-77	113	112	1	0	0	0	<0.01	ND-0.03	-
AG-13	1975-76	62	41	1	11	5	4	5.75	ND-140.	45.
	1976-77	87	23	14	32	17	1	1.02	ND-26.	5.8
AG-1,4,5,6,7,10,11,14		624	624	0	0	0	0	ND	ND	-
Total	1975-77	949	862	16	43	22	6	0.49	ND-140.	12.
Ethion										
AG-3	1975-77	113	112	1	0	0	0	<0.01	ND-0.04	-
AG-5	1975-77	111	110	1	0	0	0	<0.01	ND-0.02	-
AG-1,2,4,6,7,10,11, 13,14		725	725	0	0	0	0	ND	ND	-
Total	1975-77	949	947	2	0	0	0	<0.01	ND-0.04	-
Malathion										
AG-13	1975-77	149	145	0	3	1	0	0.02	ND-1.80	0.32
AG-1,2,3,4,5,6,7,10, 11,14		800	800	0	0	0	0	ND	ND	-
Total	1975-77	949	945	0	3	1	0	<0.01	ND-1.80	-

Table 1.1-19 Frequency and concentrations of atrazine and desethylatrazine in water collected from 11 agricultural watersheds between May 1975 and April 1977

Watershed	Period May-Apr.	Analysis (#)	Atrazine and its metabolite - Frequency and content in water (ug/l) Not Det. (<0.04)	Trace (0.04-0.09)	Low (0.1-1.0)	Medium (1.1-10.0)	High (10.1 +)	Mean	Range	SD
AG-1	1975-76	61	5	10	30	14	2	2.2	<0.04-18.2	5.7
	1976-77	54	1	1	27	20	5	3.2	<0.04-22.6	9.9
AG-2	1975-76	29	13	8	7	0	1	0.57	<0.04-13.1	4.9
	1976-77	34	22	3	8	1	0	0.17	<0.04- 1.8	0.73
AG-3	1975-76	52	0	0	22	24	6	3.2	<0.4 -31.7	10.8
	1976-77	61	1	0	33	25	2	2.0	<0.04-24.7	7.0
AG-4	1975-76	34	2	3	25	3	1	1.2	0.07-14.7	5.9
	1976-77	43	2	4	27	9	1	1.5	<0.04-27.1	8.5
AG-5	1975-76	55	4	2	37	12	0	1.0	<0.04- 6.6	3.1
	1976-77	56	3	2	38	13	0	0.89	<0.04- 7.7	2.1
AG-6	1975-76	58	23	11	23	1	0	0.13	<0.04- 1.2	0.44
	1976-77	41	26	3	12	0	0	0.07	<0.04- 0.52	0.18
AG-7	1975-76	28	11	9	8	0	0	0.10	<0.04- 0.6	0.35
	1976-77	19	19	0	0	0	0	<0.04	<0.04	-
AG-10	1975-76	24	0	0	20	3	1	1.4	0.07-10.3	5.6
	1976-77	37	1	2	18	8	8	5.5	<0.04-32.8	18.2
AG-11	1975-76	18	0	0	16	2	0	0.49	0.1 - 1.2	0.61
	1976-77	5	1	2	2	0	0	0.09	<0.04- 0.3	0.28
AG-13	1975-76	62	32	7	15	8	0	0.39	<0.04- 4.4	1.6
	1976-77	87	20	11	46	9	1	0.66	<0.04-10.8	2.9
AG-14	1975-76	48	2	6	32	7	1	1.0	<0.04-13.3	13.5
	1976-77	43	0	1	33	7	2	1.6	<0.04-18.0	21.
Total	1975-76	469	92	56	235	74	12	1.1	<0.04-31.7	6.6
	1976-77	480	96	29	244	92	19	1.6	<0.04-32.8	9.8
Grand Total:	1975-77	949	188	85	479	166	31	1.4	<0.04-32.8	8.4

Table 1.1-20 Frequency and concentration of several organonitrogen herbicides in water collected from 11 agricultural watersheds between May 1975 and April 1977

Watershed	Period May-Apr.	Analysis (#)	Frequency and content in water (ug/L) Not Det. (<0.04)	Trace (0.04-0.09)	Low (0.10-1.0)	Medium (1.1-10.)	High (10.1+)	Mean	Range	SD
Alachlor										
AG-3	1975-77	113	111	1	0	1	0	0.08	ND-9.0	1.70
AG-11	1975-77	23	22	1	0	0	0	<0.04	ND-0.07	-
AG-1,2,4,5,6,7,10, 13,14		813	813	0	0	0	0	ND	ND	-
Total	1975-77	949	946	2	0	1	0	<0.04	ND-9.0	-
Cyprazine										
AG-1	1975-77	115	113	2	0	0	0	<0.04	ND-0.07	-
AG-2	1975-77	63	60	3	0	0	0	<0.04	ND-0.07	-
AG-3	1975-77	113	111	1	0	0	1	0.16	ND-18.0	-
AG-4	1975-77	77	76	0	1	0	0	<0.04	ND-0.3	-
AG-5	1975-77	111	109	0	2	0	0	<0.04	ND-0.3	-
AG-10	1975-77	61	59	1	1	0	0	<0.04	ND-0.3	-
AG-14	1975-77	91	89	0	2	0	0	<0.04	ND-0.3	-
AG-6,7,11,13	1975-77	318	318	0	0	0	0	ND	ND	-
Total	1975-77	949	935	7	6	0	1	<0.04	ND-18.0	-
Metribuzin										
AG-1	1975-77	115	110	0	4	1	0	<0.04	ND-1.2	0.18
AG-5	1975-77	111	110	0	0	1	0	<0.04	ND-1.4	-
AG-6	1975-77	99	98	1	0	0	0	<0.04	ND-0.07	-
AG-13	1975-77	149	142	2	5	0	0	<0.04	ND-1.0	-
AG-2,3,4,7,10,11,14	1975-77	475	475	0	0	0	0	ND	ND	-
Total	1975-77	949	935	3	9	2	0	<0.04	ND-1.4	-
Prometone										
AG-5	1975-77	111	110	1	0	0	0	<0.04	ND-0.07	-
AG-6	1975-77	99	97	2	0	0	0	<0.04	ND-0.07	-
AG-10	1975-77	61	57	4	0	0	0	<0.04	ND-0.07	-
AG-13	1975-77	149	148	1	0	0	0	<0.04	ND-0.07	-
AG-1,2,3,4,7,11,14		529	529	0	0	0	0	ND	ND	-
Total	1975-77	949	941	8	0	0	0	<0.04	ND-0.07	-
Simazine										
AG-1	1975-76	61	45	12	4	0	0	0.04	ND-0.20	0.08
	1976-77	54	29	5	17	3	0	0.37	ND-3.40	1.30
AG-3	1975-76	52	50	2	0	0	0	<0.04	ND-0.07	-
	1976-77	61	55	3	3	0	0	<0.04	ND-0.50	0.14
AG-4	1975-76	34	34	0	0	0	0	ND	ND	-
	1976-77	43	39	2	2	0	0	<0.04	ND-0.20	-
AG-5	1975-77	111	103	8	0	0	0	<0.04	ND-0.07	-
AG-6	1975-77	99	98	0	1	0	0	<0.04	ND-0.10	-
AG-10	1975-76	24	23	1	0	0	0	<0.04	ND-0.07	-
	1976-77	37	26	6	5	0	0	0.04	ND-0.30	0.13
AG-13	1975-76	62	57	5	0	0	0	<0.04	ND-0.07	-
	1976-77	87	83	4	0	0	0	<0.04	ND-0.07	-
AG-14	1975-77	91	88	3	0	0	0	<0.04	ND-0.07	-
AG-2,7,11	1975-77	133	133	0	0	0	0	ND	ND	-
Totals	1975-76	469	442	22	5	0	0	<0.04	ND-0.20	0.04
	1976-77	480	421	29	27	3	0	0.06	ND-3.40	0.48
Grand Total:	1975-77	949	863	51	32	3	0	0.04	ND-3.40	0.35

Table 1.1-21 Frequency and concentration of carbamates in water collected from 5 agricultural watersheds between June-August 1976

Water-shed	Period	Analysis	Not det. (absent)	Trace (<0.5)	Low (0.5-1.0)	Mean	Range	Amount (g)
			Frequency and contents in water (ug/L)					
Carbofuran								
AG-3	June-Aug. 1976	13	8	1	4	<0.5	ND-1.0	20.7
AG-6	July-Aug. 1976	5	5	0	0	ND	ND	0.0
AG-13	June-Aug. 1976	25	20	1	4	<0.5	ND-1.0	0.3
	TOTAL	43	33	2	8	<0.5	ND-1.0	21.0
EPTC			(absent)	(0.1-0.5)				
AG-2	June-Aug. 1976	5	5	0	0	ND	ND	0.0
AG-3	June-Aug. 1976	13	13	0	0	ND	ND	0.0
AG-6	June-Aug. 1976	8	8	0	0	ND	ND	0.0
AG-7	Aug. 1976	2	2	0	0	ND	ND	0.0
AG-13	June-Aug. 1976	25	22	3	0	<0.1	ND-0.2	0.1
	TOTAL	53	50	3	0	<0.1		0.1

Table 1.1-22 Pesticides used past and present in Ontario agriculture and on roadsides with the frequency of their presence in water May, 1975 and April, 1977.

	Insecticides Present	Insecticides Past	Fungicides	Herbicides	Nematocides Growth Regulators	Others	Industrials
Project 5-Survey (4)	27	0	10	34	4	2	0
Project 4B-Analysis(#)	20	8	1	16	0	0	2
-Volume (%)	93.1		0.1	74.8	0	0	0

Frequency in Water	Insecticides	Fungicides	Herbicides	Industrials
Frequent (40 - 100%)	p,p'-DDE	---	atrazine and desethyl atrazine	PCB
Infrequent (10 - 40%)	p,p'-TDE, p,p'-DDT, dieldrin β-endosulfan & endosulfan sulfate	---	---	---
Rarely (1 - 10%)	cis & trans chlordane o,p'-DDT, diazinon α-endosulfan, heptachlor epoxide	---	2,4-D, simazine, 2,4,5-T	
Occasionally (less than 1%)	chlorpyrifos ethion, malathion	---	alachlor, cyprazine dicamba, MCPA prometone	---

Table 1.1-23

DISSOLVED ORGANOCHLORINE CONTAMINANT RESIDUES IN OAKVILLE CREEK** AND GRAND RIVER WATERS, JULY AND SEPTEMBER 1976 (ng/l) ($\bar{x}$ AND 95% CONFIDENCE LIMITS).

Chemical	# of Analyses	Oakville Creek	Grand River
PCB	9	3.5 ± 1.2	2.6 ± 0.65
HCB	9	0.04 ± 0.03	0.02 ± 0.02
χ - BHC	9	2.24 ± 1.14	1.91 ± 0.97
LINDANE	9	1.55 ± 0.8	0.67 ± 0.16
β - BHC	9	ND	ND
HEPTACHLOR	9	ND	ND
ALDRIN	9	ND	ND
HEPTACHLOR EPOXIDE	9	0.22 ± 0.13	0.42 ± 0.20
THIODAN I	9	ND	ND
THIODAN II	9	ND	ND
DIELDRIN	9	0.36 ± 0.14	0.32 ± 0.05
ENDRIN	9	0.19 ± 0.13	0.12 ± 0.10
Σ - DDT	9	0.55 ± 0.35	0.36 ± 0.13
χ - CHLORDANE	9	0.21 ± 0.03	0.13 ± 0.02
γ - CHLORDANE	9	0.14 ± 0.03	0.10 ± 0.02
MIREX	5	0.07 ± 0.04	0.08 ± 0.04*

*September values only

ND - non detectable

**In Lake Ontario Basin

TABLE 1.1-24

CONCENTATIONS OF FREONS AND CHLORINATED HYDROCARBONS IN THE OPEN WATERS OF LAKE ERIE (175)

Compound	Area	# Stations	Concentrations (ng/L) Mean of Station Means and Standard Deviations 1978	1977
Freon 11 (Trichloro fluoro methane)	Eastern Basin	15 10	57±22	136±34
	Central Basin	78 80	28±16	34±22
Freon 12 (Dichloro difluoro methane)	Eastern Basin	15 10	40±22	102±48
	Central Basin	78 80	80±31	69±33
Carbon Tetrachloride	Eastern Basin	94	19±11	
	Central Basin	92		47±41
Trichloroethylene	Eastern Basin	94	20±13	
	Central Basin	92		11±9

1.2 DATA ON SEDIMENT QUALITY - LAKE ERIE

Heavy Metals

Concern on the possible effects of mercury discharges from chlor-alkali plants along the St. Clair and Detroit Rivers resulted in the initiation of intensive sediment analyses programs in the Lake Erie Basin. The programs generally determined several heavy metal concentrations, in addition to mercury, and the results of many of the studies are noted in Table 1.2-1 (references 21-27).

The distributions of mercury in sediments of the Western Basin during 1970, 1972 and 1976 are illustrated in Figures 1.2-1 to 1.2-4. Thomas and Jaquet (25) illustrated the distribution patterns of mercury in the surficial 3 cm of sediments throughout Lake Erie in 1971 (Figures 1.2-5 and 1.2-6). The actual mean mercury levels and the ranges are shown in Table 1.2-2. The profiles of mercury concentration at various sediment depths which were determined by Kemp and Thomas (26) are shown in Figure 1.2-7. In Figure 1.2-7, Stations 4-7 for Lake Erie are located in the Western Basin; Station 8 is in the Central Basin; and, Station 9 is in the Eastern Basin. All studies appear to show higher levels of mercury in the "deeper, central part of the basin in a fanwise distribution emanating from the Detroit River mouth" (24). The Ontario Ministry of the Environment (24) stated that its "data reveal a slight decrease (not significant at a 90% confidence level) in the mean concentration when compared to earlier data. Mercury levels in 1976 exhibited an almost normal distribution compared to a heavily-skewed distribution existing in 1970..."

The Pollution from Land Use Activities Reference Group (PLUARG) in its 1977 report to the IJC, presented its findings on lead concentrations in Great Lakes sediments (28). In Figure 1.2-8, two plumes are observed: from the Detroit River to the Western Basin of Lake Erie; and, from the Cleveland Region to the Central Basin. On the basis of the 1977 PLUARG report, the following information is presented: profiles of lead in Great Lakes sediment cores (Figure 1.2-9); lead concentrations in the topmost 3 cm of Lake Erie sediments (Table 1.2-3); and a mass balance for lead in Lake Erie (Table 1.2-4).

A 1973-74 study of selenium levels in Western Lake Erie by Adams and Johnston (5), showed a range from 0.10 to 0.75 ppm selenium (Table 1.2-5).

Profiles for other metals in Lake Erie sediment cores, which were reported in 1974 by Walters _et al_. (30), are shown in Figures 1.2-10 to 1.2-13. Actual analytical data for some cores are given in Table 1.2-6.

Tables 1.2-1, 1.2-7 and 1.2-8 summarize nearshore sediment quality (22, 27) including sediments from tributary outlets (31), areas near point source discharges (22, 32) and harbors (33-40). Information in Table 1.2-8 (references 33-39) was obtained from the EPA Region V Harbor Sediment Sampling Programs.

Table 1.2-9 which is from the PLUARG Maumee River Basin Watershed Study Report (11), gives the mean heavy metal concentrations of the surface soil horizons of the Defiance County and Hoytville sites and bottom sediments from 20 sampling sites in the Maumee River.

Organic Contaminants

During investigations of the Pollution from Land Use Activities Reference Group, levels of pesticides and PCBs were determined within Lake Erie sediments (42, 43). The determined values of DDE, TDE, HEOD (dieldrin) and PCB in Lake Erie sediments are given in Table 1.2-10. Distributions of the compounds are shown in Figures 1.2-14 to 1.2-16. The results of sediment core studies and suspended solid analyses are noted in Tables 1.2-11 and 1.2-12 (43). The suspended solids were analyzed for the purpose of evaluating the role of hydraulically sorted fine fractions of sediments coming from Lake St. Clair in transporting contaminants to Lake Erie.

Organic contaminant levels in harbor and nearshore sediments of Lake Erie are shown in Table 1.2-8 and 1.2-13. The latter table also notes the organic contaminants which were not detected (27).

Pesticide scans were made of seven Maumee watershed surface soils and the bottom sediments of three rivers in the watershed (11). Six organophosphate standards were used in the scans, however, the observed peaks did not correspond to any of the standards. The peaks observed were likely due to phosphate or phosphorylated compounds, but the identity remained unresolved. Thirteen organochlorine pesticides were sought. Of seven surface soil samples, one sample contained 0.9 ppb p,p'-DDD; of the three river samples, a sample from the Auglaize River contained 2.8 ppb p,p'-DDD and a sample from the Tiffin River contained 0.5 ppb o,p-DDD and 0.9 ppb dieldrin. A sediment sample from the Maumee River contained no organochlorine pesticides above the detection level.

Table 1.2-14 summarizes the residues of pesticides found in stream bed sediments in eleven agricultural watersheds in Southern Ontario from 1974-77 (170). Watersheds AG-2, AG-4 and AG-13 are within the Lake Erie Basin and are described in Table 1.1-11. Another PLUARG study evaluated organochlorine residues associated with suspended solids in the waters of the Grand River (171). The results are shown in Table 1.2-15.

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TABLE 1.2-1

LAKE ERIE SEDIMENTS - METAL ANALYSES

SAMPLE DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	CONCENTRATION - ppm dry weight								INFORMATION SOURCE
			MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	
1967-68	Island Area - Lake Erie	6	0.5-.9								21
1970	Detroit River Mouth		1.4	5.9	150	20		<30	30	36	22
1970	Detroit River Light		2.9	160	600	100		<30	190	140	22
1970	Monroe, Raisin River		<1.0	150	360	50		<30	60	58	22
1970	Monroe Navigation Channel		3.0	150	500	100		<30	200	160	22
1970	Maumee River Mouth		<1.0	34	96	40		<30	24	27	22
1970	Maumee River		<1.0	140	330	50		<30	100	79	22
1970	Black River Mouth		<1.0	82	340	40		<30	68	78	22
1970	Ashtabula River Mouth		1.1	79	300	60		<30	910	44	22
1970	Cleveland Harbor		<1.0	340	1200	60		<30	200	150	22
1970	Fairport Harbor		2.0	51	240	30		<30	210	34	22
1970	Presque Isle Bay		1.1	200	550	50		<30	110	140	22
1970	Buffalo River Mouth		2.6	420	1200	40		<30	260	210	22
1970	Sandusky Bay		<1.0	62	160	20		<30	33	49	22
1970	Lake Erie - 3 mi. No. of Dunkirk		<1.0	100	390	50		<30	67	57	22
	5- 5 mi. No. of Vermillion		<1.0	97	250	40		<30	67	61	22
	- 1 mi. No. of Vermillion		<1.0	73	140	30		<30	20	32	22
	- 2 mi. No. of Cleveland east entrance		<1.0	64	200	20		<30	36	36	22
	- 3.25 mi. No. of Cleveland Harbor		2.4	85	260	20		<30	31	39	22
1970	Lake Erie - Western Basin	11		86±48 (30-173)	224±16 (54-530)		7.9±2.5 (4-12.3)	5.4±3.8 (2.2-13.7)	177±119 (50-362)	79±46 (30-183)	23
1970	Lake Erie Western Basin (See Fig. 1.21)	36	1.29±1.04 (0.05-4.6)								24
1970	Lake Erie - Western Basin (See Fig. 1.2-3)	28	<0.5 (wet weight)								22
		16	0.8-2.1 (dry weight)								
(1976)	Lake Erie - Western Basin (See Fig. 1.2-2	57	(002-1.92) .969+.523								24
1970	Lake Erie Basin	48	1-8								22
	Areas > 1 ppm										
	- Black River		8								
	- Cleveland Easterly STP outfall area		4								

TABLE 1.2-1 CONT'D

SAMPLE DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	CONCENTRATION - ppm dry weight: MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	COBALT	INFORMATION SOURCE
	- Ashtabula River	2	<1-2									
	- Buffalo River	4	1-4									
1970	Maumee River	5	<0.5 (wet weight)									22
1971	Lake Erie	259	0.58±0.56									
	(see Figs. 1.2-5, 1.2-6		(0.008-2.93)									25
	Table 1.2-2											
1973	Michigan nearshore waters											
	- Lake Erie											
	-North region		.95±.21	61.6±14.7	249±41	49±14	<2.4±1.1	4.6±1.4	49±14	50±10		27
	-South region		.19±.05	17.2±5.5	69±13	22± 9	<2.5±1.1	1.6± .6	14± 3	19±11		
1973	Port Colborne											
	- Immediate vicinity of	2		305-398		4800-5630				245-351	235-248	32
	Algoma, Inco Effluent											
	Discharges											
	- Nickel Beach	7		18.9-57.7		115-796				7.7-35.6	15-53.5	
	- Welland Canal	2		59.4-73.4		97.2-257				35.8-44.5	16.9-32.7	
1973	Ashtabula Harbor											
	-Control Area	25	0.29-0.82					2.3-4.3	56-89			33
	-Previous Dumping Site	7	0.25-1.1					3.8-12.9	70-122			
1974	Ashtabula Harbor	7	<0.2-4.6	<10-20	130-150	130-210	7-25	4-12	42-2100	16-30	<6-42	34
1975	Ashtabula Harbor	11	<0.1	12-36	106-156	19-38	11-16	<1	22-82	26-48		35
1974	Conneaut Harbor	10	<0.2-0.7	10-50	100-140	110-270	7-15	1.9-7.4	23-49	15-54	14-36	36
1974	Port Clinton Harbor	1	0.2	<10	10	40	<2	3.5	6	<3	11	37
1974	Fairport Harbor	12	<0.4-0.6	20-50	100-400				44-102			38
1975	Fairport Harbor	10	<0.1	13-57	80-161	16-40	6-16	<1-2.5	55-130	26-46		39
1974(?)	Western Basin			30-173						30-183		40
	Leamington			8.8-12.2								40
	Port Stanley			34.1-82.6						30.4-44.8		
	Port Burwell			18.8-29.9						14.6-19.6		
1974	Lake Erie (see Figs. 1.2-10 to											
	1.2-14, Table 1.2-6)	8	✓		✓	✓	✓	✓	✓	✓	✓	30
1975	Grand River	1	1.02	30				2				40
	Grand River Mouth	1	0.21	15				<1				
	Splatt Bay - Adjacent to											
	Grand River	8	0.02-0.18	7.7-31				<1-1.5				
1976	Lake Erie	257		87±50								28
	(see Figures 1.2-8,1.2-9 and											
	Table 1.2-3, 1.2-4)											
1976-77	Lake Erie Harbors-see Table 1.2-8											41

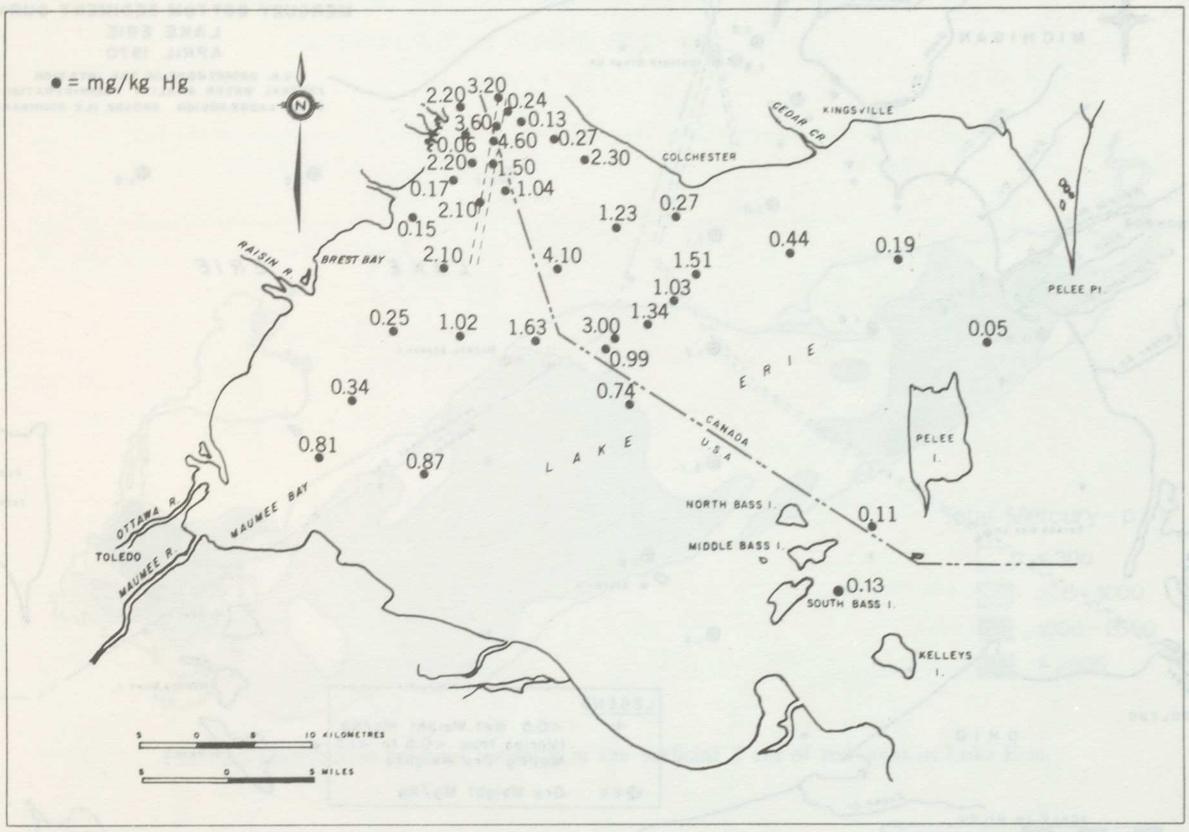


FIG. 1.2-1 SEDIMENT SAMPLING LOCATIONS AND OBSERVED CONCENTRATIONS - MERCURY SURVEY 1970, MINISTRY OF THE ENVIRONMENT.

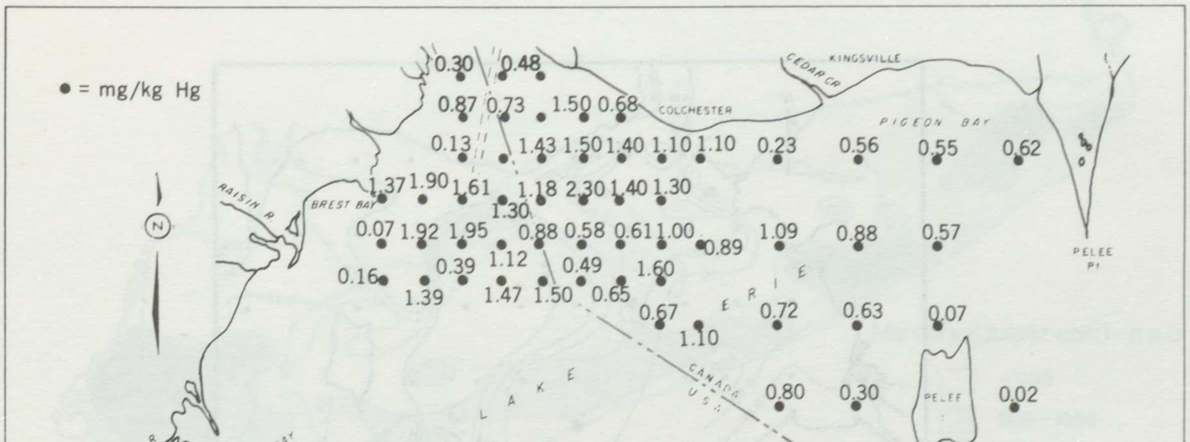
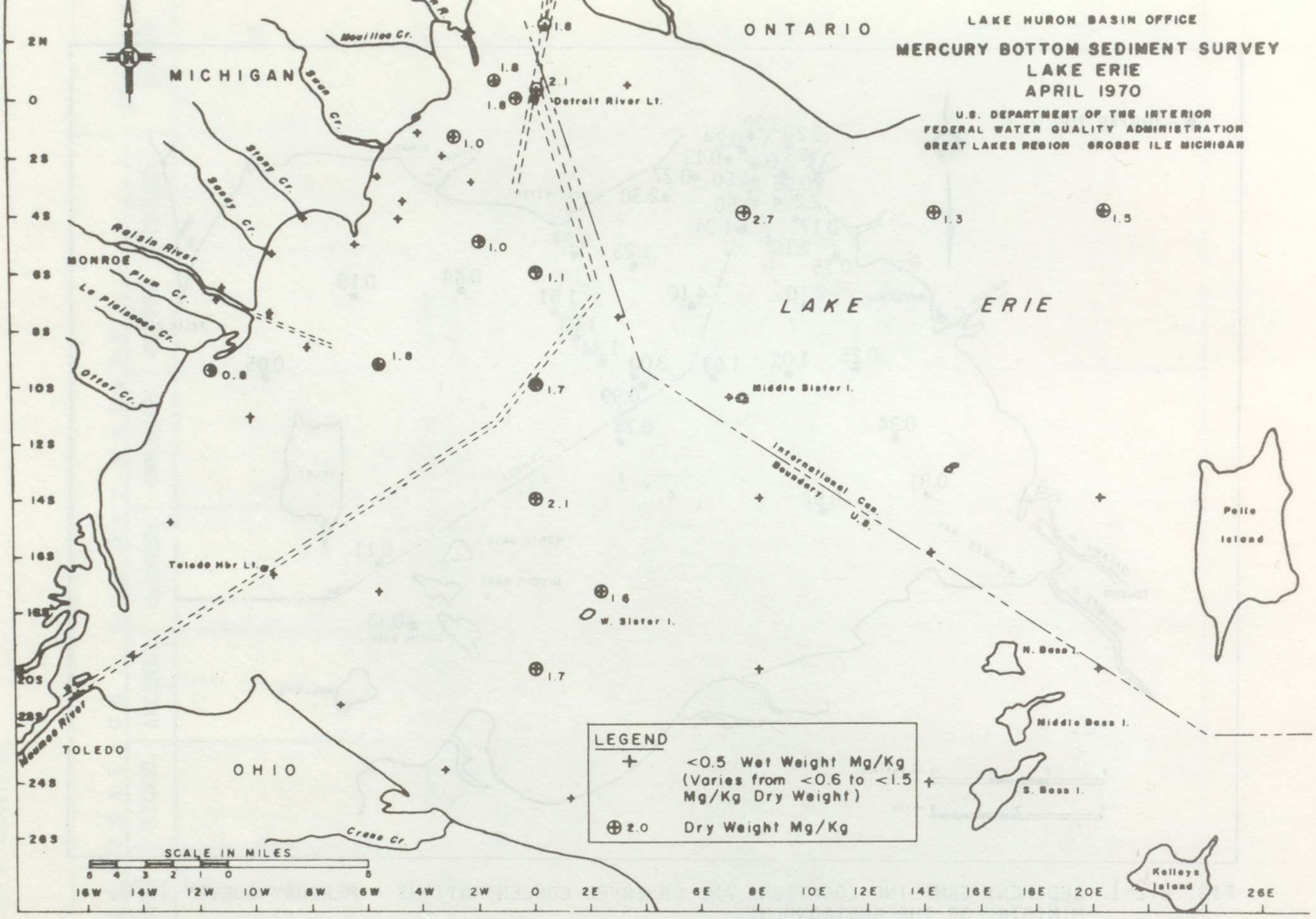


FIG. 1.2-2 SEDIMENT SAMPLING LOCATIONS AND OBSERVED CONCENTRATIONS - MERCURY SURVEY 1976, MINISTRY OF THE ENVIRONMENT.

FIG. 1.2-3



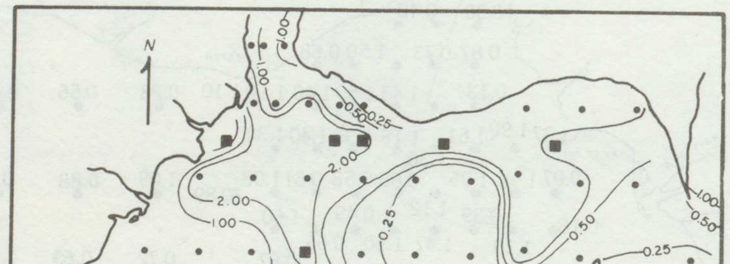


FIG. 1.2-4[(a)] MAP OF MERCURY CONTENT (PPM, DRY WEIGHT BASIS) OF SURFACE SEDIMENTS IN WESTERN BASIN OF LAKE ERIE (1972). CONTROL IS SHOWN BY STATION LOCATIONS FOR DATA.

(a) REFERENCE 29

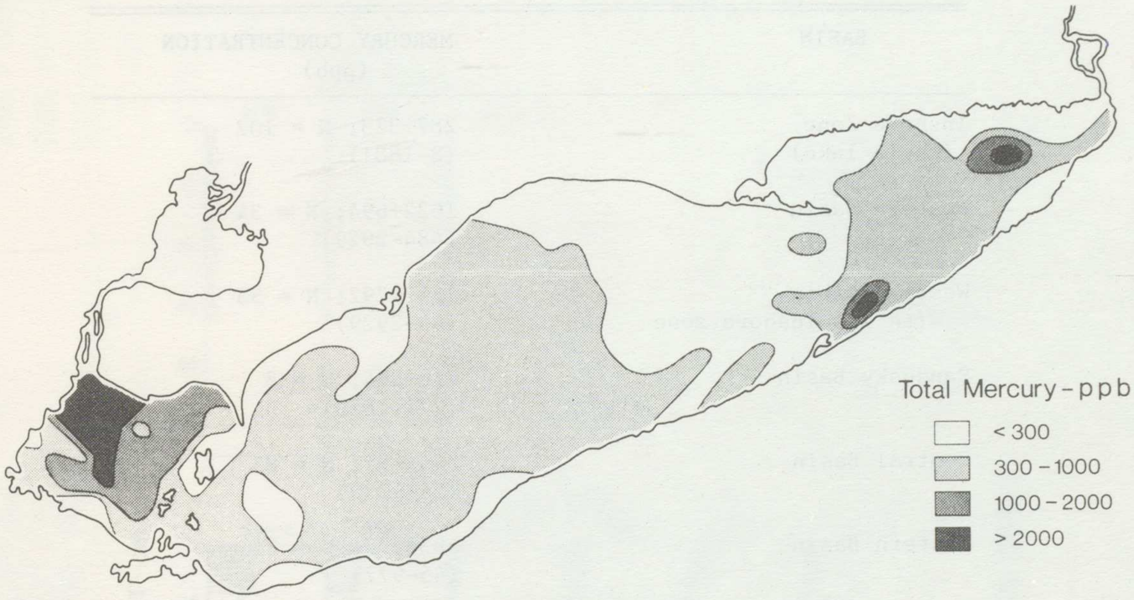


FIG. 1.2-5 Distribution of total mercury in the surficial 3 cm of sediment in Lake Erie.

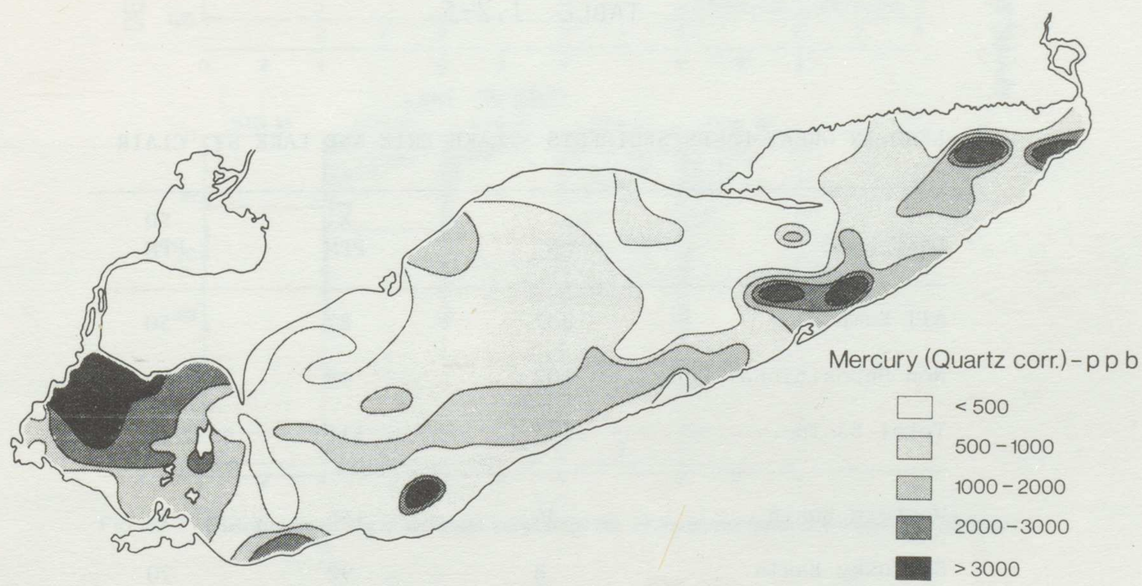


FIG. 1.2-6 Distribution of quartz-corrected mercury in the surficial 3 cm of sediment in Lake Erie.

TABLE 1.2-2

MERCURY LEVELS (MEANS ± SD) IN THE SEDIMENTS OF LAKE ERIE (RANGE IN PARENTHESES).

BASIN	MERCURY CONCENTRATION (ppb)
Inshore Zone (whole lake)	287±323; N = 102 (8-1881)
Western Basin	1622±694; N = 34 (484-2929)
Western Basin with its inshore zone	1217±792; N = 53 (65-2929)
Sandusky Basin	710±464; N = 8 (271-1810)
Central Basin	544±191; N = 85 (56-1030)
Eastern Basin	483±272; N = 31 (45-977)
Total	582±555; N = 259 (8-2929)

TABLE 1.2-3

LEAD IN GREAT LAKES SEDIMENTS - LAKE ERIE AND LAKE ST. CLAIR

LAKE ERIE	N	$\overline{X}$ PPM	SD PPM
All Samples	257	87	50
Non Depositional Zone	102	48	30
Total Basin	155	112	44
Western Basin	34	145	52
Sandusky Basin	8	92	20
Central Basin	83	111	34
Eastern Basin	30	81	35
Lake St. Clair	50	26	14

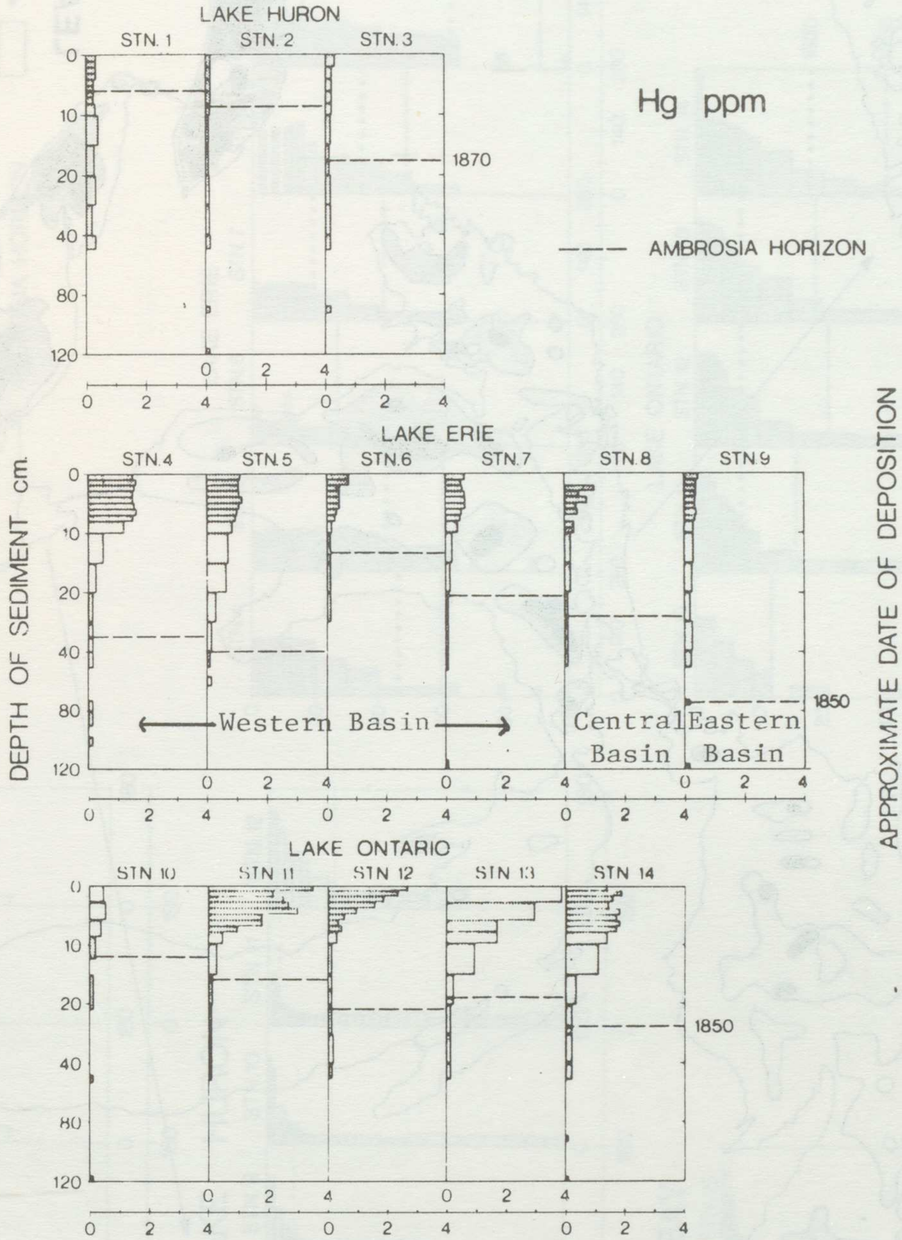


Fig 1.2-7 Distribution of Hg in sediment cores from the 14 locations (ppm dry weight of sediment).

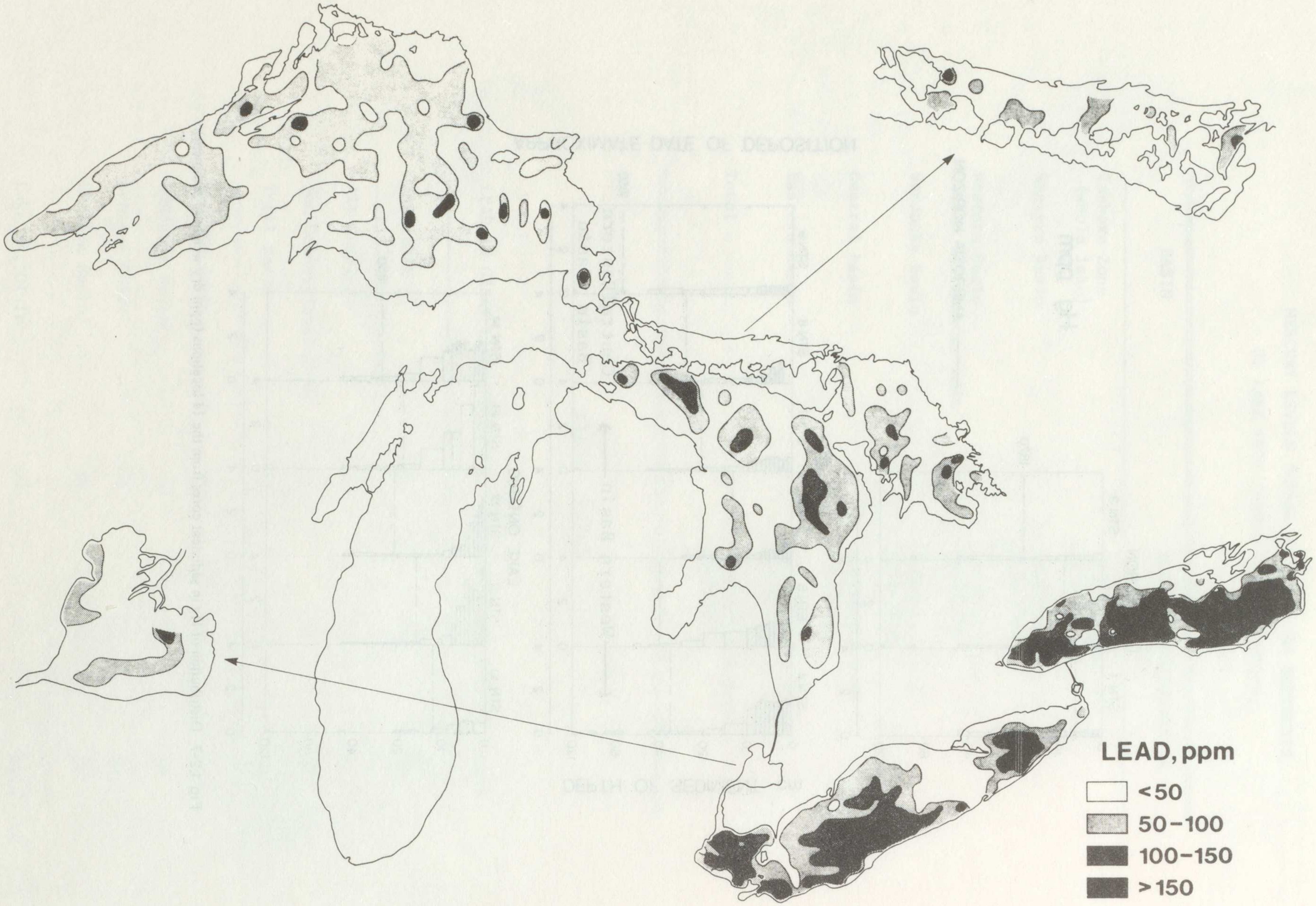


FIGURE 1.2-8 DISTRIBUTION OF PB IN LAKE SEDIMENTS: 0-3 CM SEDIMENT THICKNESS

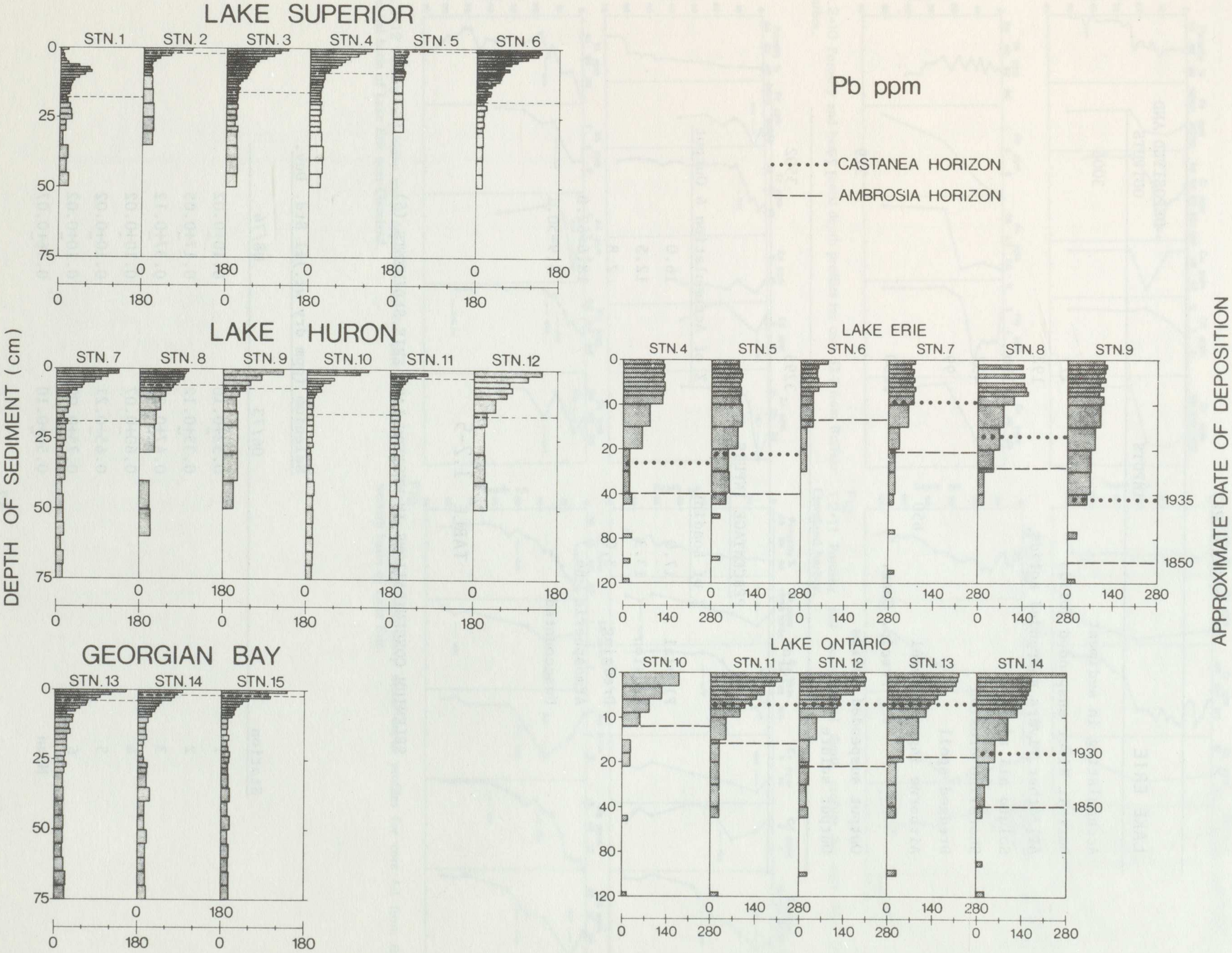


FIG 1.2-9 PROFILES FOR LEAD IN SEDIMENT CORES FROM THE GREAT LAKES

TABLE 1.2-4

LEAD MASS BALANCE (METRIC TONS PER ANNUM) - LAKE ERIE

(Ref. 28)

LAKE ERIE		INPUTS	DEPOSITED AND OUTPUTS
Accumulating in sediment			3006
Detroit River suspended solids		171	
All other rivers suspended solids		192	
Solute all rivers		196	
Shoreline erosion		437	
Dredged spoil		99	
Airborne inputs Model	650		
Precip. Chem.		2200	
Output suspended solids			319
Output solute			177
Total		3295	3502

PERCENTAGE INPUTS

	% of Loading	% of Accumulation & Output
Fluvial	17.0	16.0
Erosion	13.3	12.5
Dredging	3.0	2.8
Atmospheric	66.7	18.6-62.8
Unaccounted	-	5.9-50.1

TABLE 1.2-5

SELENIUM CONCENTRATIONS IN WESTERN LAKE ERIE SEDIMENTS (5)

	Selenium (ppm dry wt.)±1 Std. Dev.	
Station	06/73	08/74
1	0.52±0.10	0.10±0.02
2	0.35±0.12	0.17±0.05
3	0.47±0.21	0.37±0.12
4	0.60±0.07	0.10±0.02
5	0.65±0.21	0.10±0.02
6	0.75±0.09	0.10±0.02
Mean	0.56±0.10	0.16±0.07

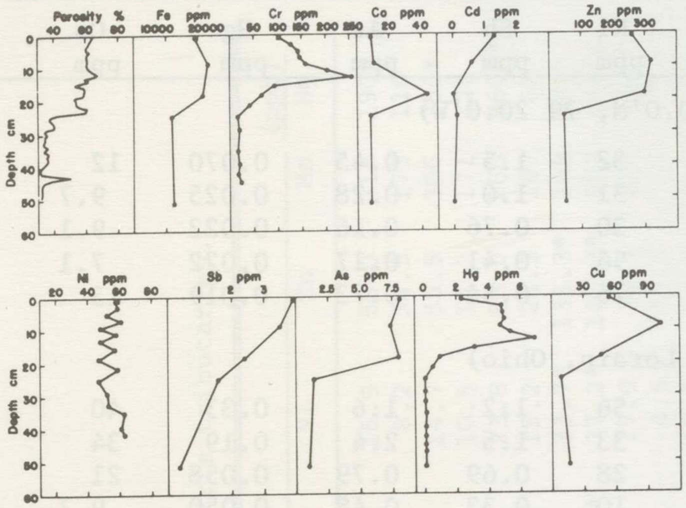


Fig. 1.2-10 Porosity and heavy metal depth profiles for core 32-2 from Buffalo harbor.

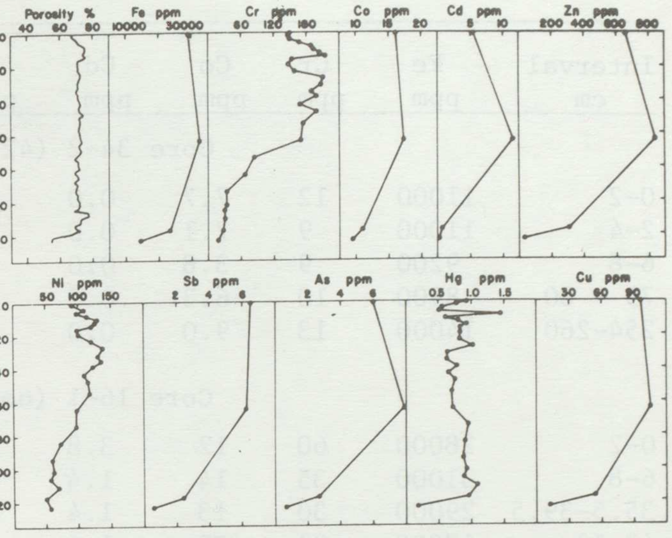


Fig. 1.2-11 Porosity and heavy metal depth profiles for core 20-1 from Cleveland harbor.

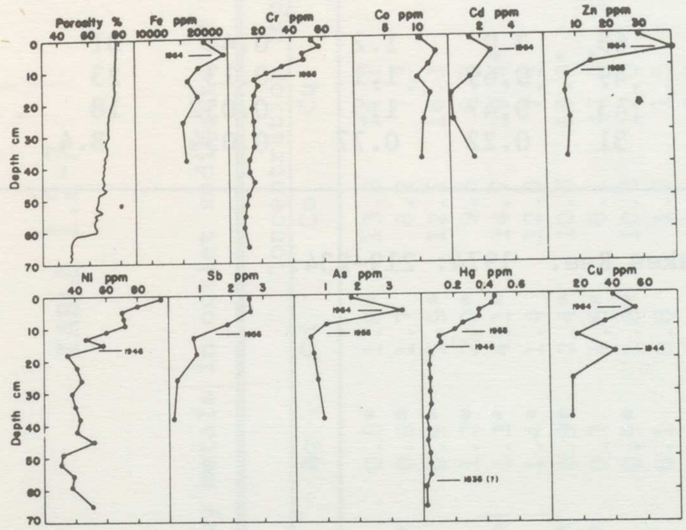


Fig. 1.2-12 Porosity and heavy metal depth profiles for core 19-1 from the central basin of Lake Erie near Cleveland.

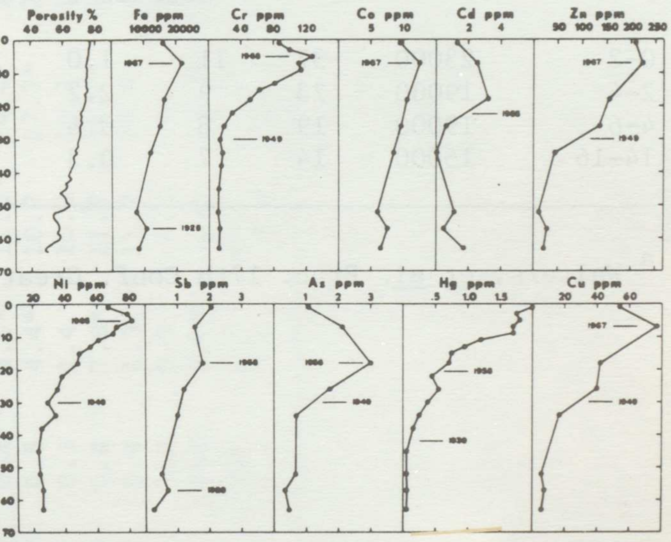


Fig. 1.2-13 Porosity and heavy metal depth profiles for core 4-1 from the western basin of Lake Erie.

TABLE 1.2-6

HEAVY METAL CONCENTRATION IN LAKE ERIE SEDIMENT CORES[a]

Interval cm	Fe ppm	Cr ppm	Co ppm	Cd ppm	Zn ppm	Ni ppm	Sb ppm	As ppm	Hg ppm	Cu ppm
Core 34-2 (42 40.0'N, 79 20.0'W)										
0-2	11000	12	7.7	0.0	53	32	1.5	0.45	0.070	12
2-4	11000	9	7.1	0.0	21	31	1.0	0.28	0.025	9.7
6-8	9200	9	3.8	0.0	35	30	0.76	0.16	0.022	9.1
75 - 80	8900	10	6.3	0.2	25	56	0.41	0.17	0.022	7.1
254-260	14000	13	9.0	0.0	37	76	0.54	0.73	0.019	13
Core 16-1 (near Lorain, Ohio)										
0-2	28000	60	12	3.8	26	56	1.2	1.6	0.33	40
6-8	31000	35	14	1.4	20	33	1.5	2.4	0.19	34
35.5-39.5	29000	30	13	1.4	17	28	0.69	0.79	0.058	21
47-50	17000	21	10	1.6	8	10	0.33	0.48	0.050	9.7
Core 13-2 (near Pelee Lorain sill)										
0-2	23000	37	11	1.0	18	65	2.0	1.2	0.44	31
2-4	19000	23	9	2.2	12	49	0.69	1.1	0.13	23
4-6	19000	19	8	0.6	9	43	0.47	1.5	0.052	18
14-16	15000	14	7	0.3	5	31	0.22	0.77	0.054	8.4

[a] Walters, _et_ _al_. Proc. 17th Conf. Great Lakes Res. 1974: 219-234.

TABLE 1.2-7

Concentration of heavy metals in outlet sediments of Lake Erie tributaries.

Site	Concentration (ppm)									(ppb)
	Pb	Ag	Cd	Co	Cu	Cr	Ni	Zn	Mn	Hg
Grand River	13.3	0.8*	1.8*	13.8	14.1	11.8	16.9	56.0	218	190*
Lynn River	28.7*	0.8*	1.7	8.2	7.3	5.8	8.2	34.5	170	110
Big Otter Creek	21.9	0.9*	1.9*	12.1	16.3	12.9	14.7	55.5	306	350*
Catfish Creek	11.2	1.2*	2.0*	9.5	6.8	5.4	10.5	14.2	171	120
Kettle Creek	40.1*	1.3*	4.1*	14.7	29.4*	22.7*	23.8	86.0	260	860**
Muddy Creek	13.5	1.4*	1.4	12.0	7.5	7.5	15.2	24.3	187	60
Raisin River	28.8*	0.9*	2.4*	10.0	69.8*	53.0*	33.7*	135.3*	189	450*
Maumee River	54.2*	0.7	4.5*	8.6	47.0*	113.2**	37.2*	146.3*	167	690**
Portage River	14.3	0.9*	1.8*	10.3	12.0	12.1	17.9	38.5	150	140*
Sandusky Bay Mouth	3.3	0.1	0.6	1.8	1.5	3.6	4.5	15.7	53	80
Huron River	9.5	0.3	1.0	6.6	8.4	10.9	12.4	40.8	136	230*
Vermillion River	21.9	0.4	2.0*	12.0	24.4*	15.6	27.5	104.7	184	210*
Black River	35.3*	0.5	4.4*	10.7	27.7*	24.7*	26.6	133.7*	195	430*
Rocky River	33.0*	0.3	1.4	10.3	19.7	14.8	20.8	101.7	132	130*
Cuyahoga River	90.6*	0.4	7.8*	11.8	55.7*	74.4*	35.5*	220.8*	163	470*
Chagrin River	20.5	0.4	1.3	11.2	20.4	15.4	20.3	64.7	350	330*
Grand River	7.9	0.2	0.9	5.3	6.5	15.7	9.8	42.5	117	100
Ashtabula River	26.6	0.4	2.6*	11.5	22.3*	124.5**	26.3	134.3*	272	370*
Conneaut River	18.1	0.5	1.3	10.7	24.7*	18.3*	27.5	80.5	238	270*
Silver Creek	15.5	0.4	1.1	9.8	18.6	27.0*	22.3	61.4	203	70

*"elevated levels"
**"excessive levels"

TABLE 1.2-8

U.S. EPA REGION V ANALYSES OF SEDIMENTS IN LAKE ERIE HARBOURS

HARBOUR/YEAR SAMPLED	TOTAL PCBs (mg/kg dry weight) LOW	HIGH
Monroe, MI /1976	<1	<1
Fairport, OH /1977	.07	1.10
Ashtabula, OH /1977	<.1	7.68
Conneaut, OH /1977	.03	.17
Sandusky, OH/1977	.17	.64
Cleveland, OH /1977	<.01	2.30
Cuyahoga River, OH/1977	.29	2.20
Elk Creek, PN/1977	.02	.08

HARBOUR (Designated Heavily Polluted re:Cd)	CADMIUM (mg/kg) (1975-76)	# VALUES >6 mg/kg
Conneaut, OH	6.1 - 7.4	5
Monroe, MI	7.0 - 7.4	2
Lorain, OH	7.7 - 29.0	6
Erie, PA	11 - 33	8
Elyria, Black River, OH	9 - 990	9

HARBOUR (Designated Heavily Polluted re: Pb)	LEAD (mg/kg) (1975-76)	# VALUES >60 mg/kg
Lorain OH	62 - 216	8
Erie, PA	69 - 255	6
Monroe,MI	75 - 120	6
Rocky River, OH	67 - 100	3
Toledo, OH	62 - 64	3
Sandusky, OH	68 - 86	2
Elyria, Black River, OH	62 - 4600	10

HARBOUR (Designated Heavily Polluted re: As)	ARSENIC (mg/kg) (1975 - 76)	# VALUES >8 mg/kg
Erie, PA	10 - 18	12
Ashtabula, OH	11 - 16	11
Lorain, OH	11 - 19	10
Fairport, OH	10 - 17	9
Sandusky, OH	10 - 19	9
Huron, OH	9 - 22	9
Monroe, MI	9 - 12	7
Vermilion, OH	11-19	8
Toledo, OH	9 - 14	6
Conneaut, OH	9 - 15	5
Rocky River, OH	11 - 15	4
Pt. Clinton, OH	11 - 12	2
Elyria, OH	9 - 16	5

TABLE 1.2-9
(Ref. 11)

Concentrations of heavy metals in Maumee River Basin soils, bottom sediments and limestone bedrock.

	Soils			Sediment			Bedrock
	Range	Mean	S.D.	Range	Mean	S.D.	Mean
				μg/g			
Cd	0.10-0.70	0.35	0.26	0.04- 0.39	0.15	0.09	1.94
Co	1.80-2.30	1.98	0.22	4.25-14.31	9.11	2.26	1.27
Cr	12.00-13.80	15.30	4.17	0.72- 2.54	1.55	0.46	2.63
Cu	9.60-27.80	20.20	8.62	4.38-10.11	6.49	1.27	8.52
Ni	25.80-42.00	33.75	6.63	6.42-16.89	11.21	2.39	34.12
Pb	21.60-29.40	25.20	3.23	3.84-10.70	7.33	1.55	33.50
Zn	41.30-69.60	49.15	13.65	6.95-24.68	15.77	3.32	250.50
Sr				50.10-93.60	71.77	7.89	57.80

TABLE 1.2-10 (1)

LAKE ERIE SEDIMENTS - ORGANIC CONTAMINANT ANALYSES

Mean levels of PCB's, DDE, TDE and Dieldrin in Lake Erie surface sediments, 1971.
All values in parts per billion.

Lake Sector	PCB's				DDE				TDE				DIELDRIN			
No. of Samples	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Total Lake (255)	95	114	4	800	8.2	11.4	0.2	136.0	18.4	21.9	0.3	186.0	1.6	0.9	0.5	5.0
Non Depositional Zone (103)	64	105	8	800	4.5	4.0	0.2	22.7	10.5	16.1	0.3	146.0	1.4	0.8	0.5	3.5
Total Basin (152)	115	114	4	660	10.7	13.9	0.5	136.0	23.7	23.7	0.4	186.0	1.7	1.0	0.5	5.0
Western Basin (32)	252	156	4	660	22.1	26.2	1.7	136.0	46.5	38.8	2.8	186.0	1.4	0.8	0.6	3.3
Central Basin (84)	74	56	12	330	7.4	3.2	0.5	18.7	18.3	9.5	0.4	55.0	1.7	1.0	0.5	5.0
Eastern Basin (29)	86	85	12	320	8.9	7.4	0.6	30.0	17.9	17.6	0.5	61.0	2.3	1.1	0.6	3.8
Sandusky Basin (7)	107	46	50	170	5.8	1.6	3.6	8.2	9.3	3.9	3.1	15.3	1.0	0.5	0.6	2.0

(1) Ref. 42 and 43

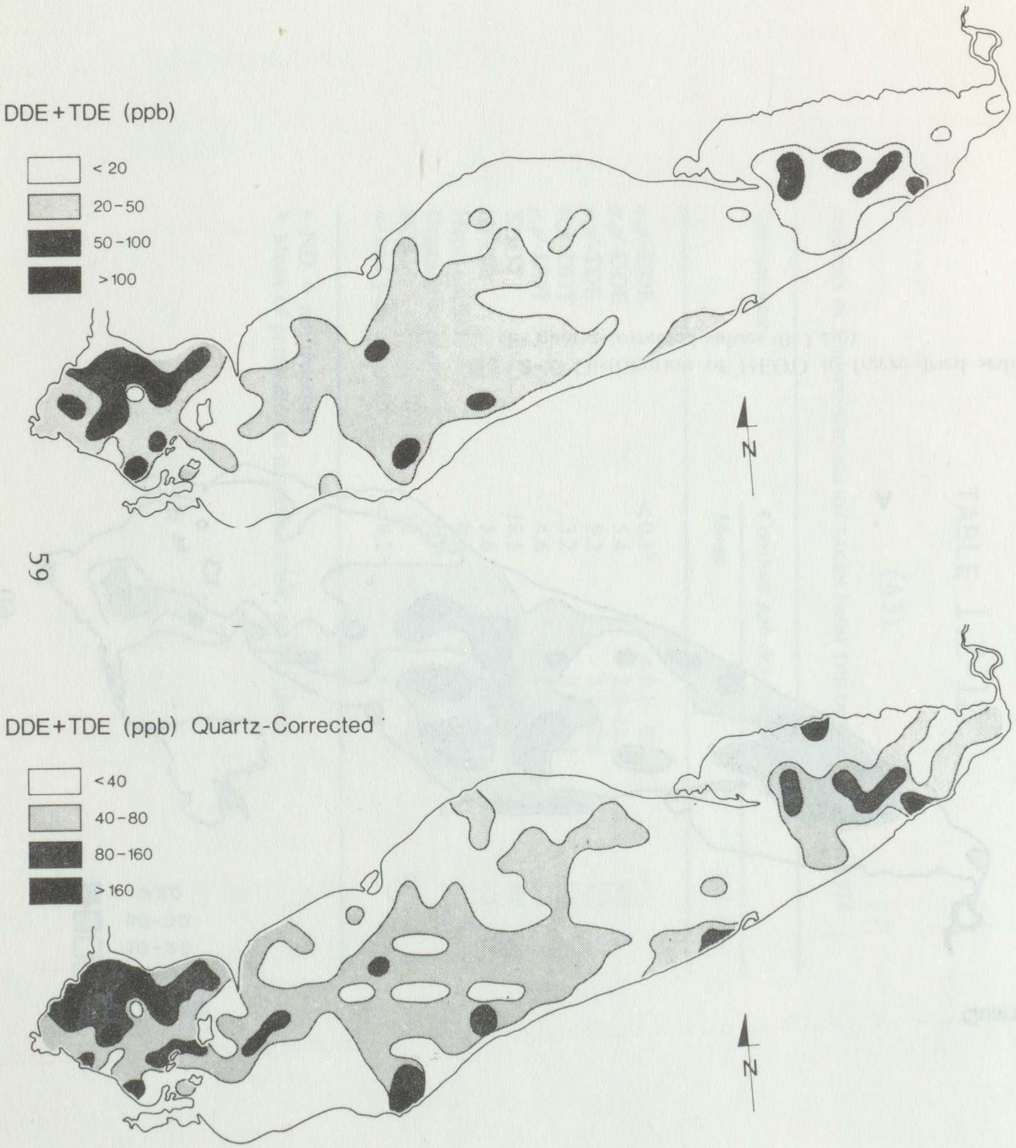


Fig.1.2-14 Distribution of TDE + TDE in freeze-dried sediments from Lake Erie; observed and quartz-corrected values (0–3 cm).

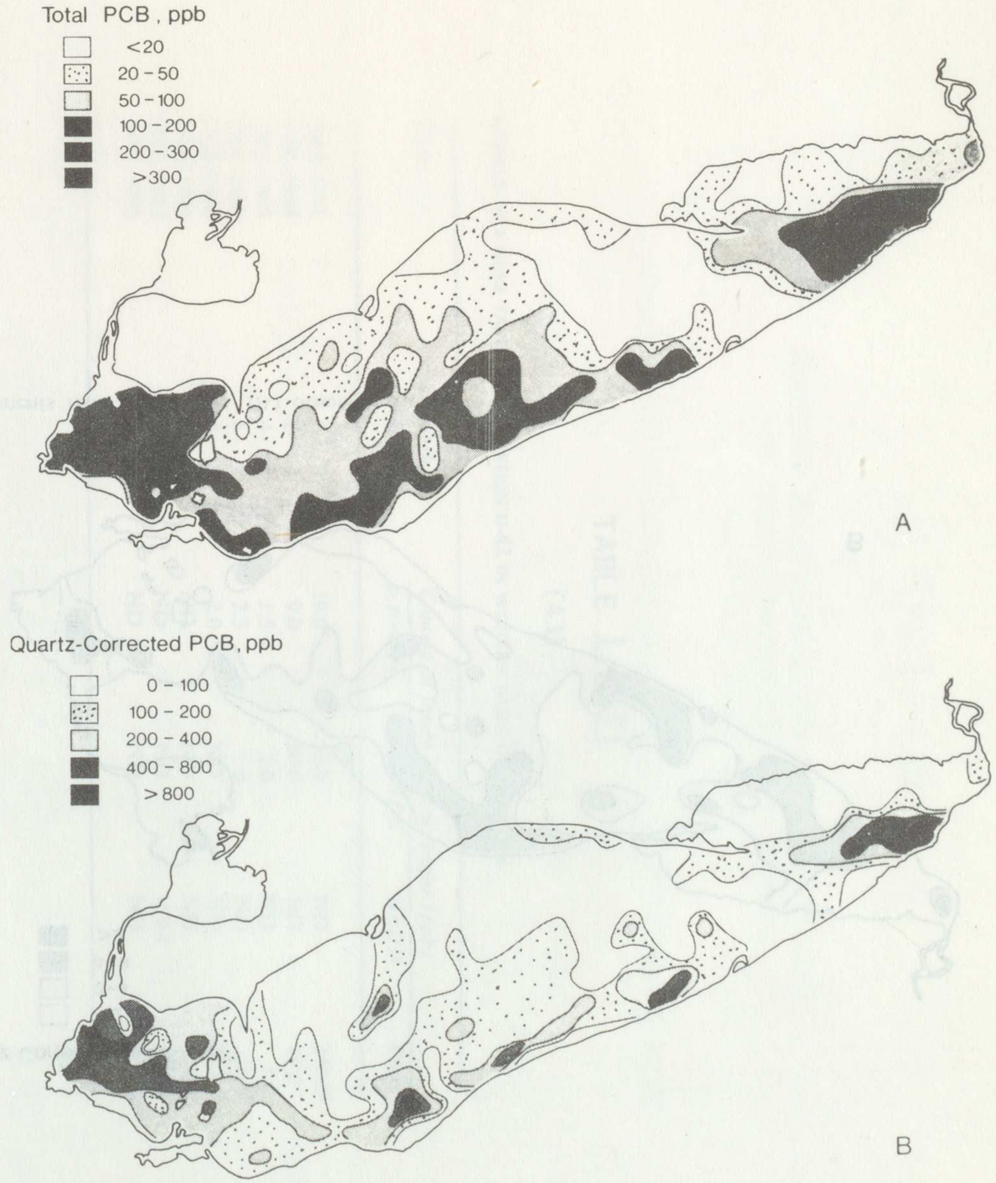


Fig.1.2-15 Distribution of PCBs in freeze-dried sediments from Lake Erie. (A) observed values; (B) quartz-corrected values (0–3 cm).

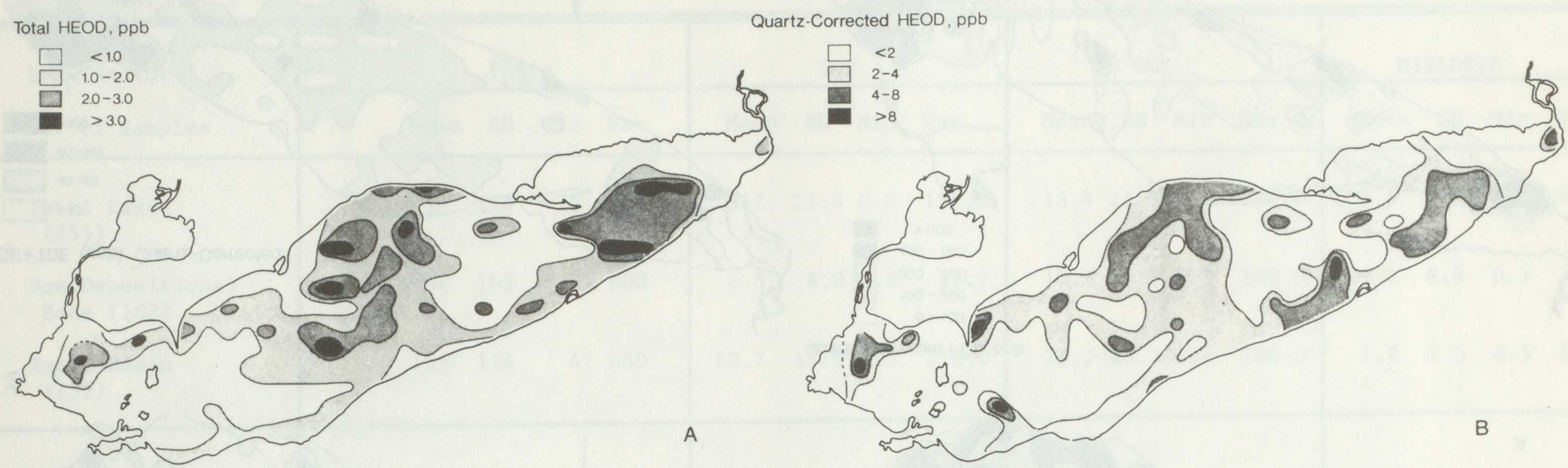


Fig. 1.2-16 Distribution of HEOD in freeze-dried sediments from Lake Erie. (A) observed values; (B) quartz-corrected values (0–3 cm).

TABLE 1.2-11

(43)

RESIDUE IN A CORE TAKEN FROM STATION U-42 IN WESTERN BASIN OF LAKE ERIE

Years	*Depth (cm)*	*Content in freeze-dried sediment (ppb)*			
		p,p'-DDE	*p,p'-TDE*	*HEOD*	*PCB*
1969–1971	0– 2	19.0	53.0	ND	340.0
1966–1968	2– 4	9.0	20.0	ND	10.0
1963–1965	4– 6	1.5	2.0	ND	6.0
1961–1963	6– 8	2.5	1.0	ND	10.0
1958–1960	8– 10	2.0	ND	ND	ND
1956–1958	10– 12	ND	ND	ND	1.0
1953–1955	12– 14	ND	ND	<0.1	ND
1827–1952	14–112	ND	ND	ND	ND

TABLE 1.2-12

(43)

RESIDUES IN 5 SUSPENDED SOLIDS TAKEN FROM THE DETROIT RIVER IN 1974

Contaminant	*Constant ppb dry weight basis*		
	Mean	*Range*	*Std. Dev.*
o,p'-DDE	<0.1[b]	<0.1– 0.2	—
p,p'-DDE	5.4	2.0–12.0	3.9
p,p'-TDE	5.2	3.1–10.0	3.2
o,p'-DDT	3.2	0.9– 6.1	1.8
p,p'-DDT	4.6	2.1– 7.1	2.3
ΣDDT	18.5	10.0–27.0	7.6
HEOD	3.6	1.9– 5.1	1.1
Hept. epoxide	0.6	ND– 2.0	
Organophosphorus	ND[a]	ND	—
PCB	72	30 –100	28
α- and γ-chlordane	<0.2[b]	<0.2	—

[a] ND = not detected
[b] Mean of parameter at detection limit; no SD given.

TABLE 1.2-13

SURVEY ORGANIC CONTAMINANTS IN SEDIMENT
SAMPLES FROM NEARSHORE WATERS OF
LAKE ERIE - 1973(a)

ORGANIC CONTAMINANTS SOUGHT AND DETECTION LIMITS(mg/kg)

DDE	- .001 - .002	Chlordane	- .005
TDE	- .001 - .002	Lindane	- .001
o,p DDT	- .001 - .002	Aldrin	- .001
p,p DDT	- .001 - .002	Endrin	- .001
Dieldrin	- .001	Heptachlor	- .001
DEHP	- 1.0	PCB	- .03-.05
DBP	- 1.0		

LOCATION	ORGANIC CONTAMINANTS FOUND IN EXCESS OF DETECTION LIMITS AND CONCENTRATIONS(mg/kg) AT STATIONS DETECTED
Plume of Detroit River 18 stations (Detroit River mouth to Stoney Point)	DDE - .006, .004, .003, .002, .006, .018 TDE - .012, .011, .008, .002, .012, .030 o,p DDT - .002, .003 p,p DDT - .006, .013, .006, .009, .007, .015 PCB - Aroclor 1260 - .38, .15, .20, .10, .08, .16 DEHP - 5.0, 3.0, 1.0, 2.0 DBP - 3.0, 6.0
Stoney Point to Woodtick Peninsula - 17 stations	DEHP - 1.0, 1.0

(a) Michigan Department of Natural Resources

Table 1.2-14 Residues of Pesticides and Pollutants found in stream bed sediment collected May 1976 - April 1977

Component	Content in Dried Sediment (ng/g)										
	AG-1	AG-2	AG-3	AG-4	AG-5	AG-6	AG-7	AG-10	AG-11	AG-13	AG-14
DDE	3.0	4.0	1.0	0.8	0.5	0.9	0.5	0.9	0.5	5.0	0.3
TDE	0.3	2.0	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	9.0	0.2
DDT	0.3	7.0	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	9.0	0.2
ΣDDT	3.6	13.0	1.7	1.0	0.7	1.1	0.7	1.1	0.7	23.0	0.5
Dieldrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2.2	<0.2
Endosulfan	16.0[3]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane	1.5	0.3	0.3	ND	ND	ND	ND	ND	ND	1.8	ND
Hept. Epox.	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND
PCB	4	4	8	6	4	6	<2	6	8	6	5
	Content in Dried Sediment (ug/g)										
2,4,5-T	ND	ND	ND	ND	3	4	14	ND	4	ND	6
Atrazine-April	ND	ND	ND	ND	ND	ND	ND	ND	15.8[1]	ND	ND
May-Oct	ND	ND	ND	20[2]	ND	7[2]	ND	ND	ND	ND	7[2]
Simazine	ND	ND	ND	ND	ND	ND	ND	ND	<1.0	ND	ND
2, 4-D	ND	ND	ND	ND	2	2	6	ND	4	ND	ND

[1] 15.8 - 7.6 ug/g atrazine and 8.2 ug/g desethylatrazine (April, 1977)

[2] Present as atrazine only (October)

[3] Endosulfan 16.0 ng/g (α-endosulfan 13 ng/g, β-endosulfan 2.2 ng/g, and endosulfan sulfate 0.8 ng/g)

Table 1.2-15

ORGANOCHLORINE RESIDUES ASSOCIATED WITH SUSPENDED SOLIDS IN OAKVILLE CREEK* AND GRAND RIVER WATERS (DRY WEIGHT ng/g) ($\bar{x}$ and 95% CONFIDENCE LIMITS).

	July			September	
July	Oakville Creek	Grand River	September	Oakville Creek	Grand River
# of Analyses	5	4		5	4
PCB	76 ± 60	55 ± 43		384 ± 377	49 ± 41
HCB	ND	ND		ND	ND
χ - BHC	TR	1.6 ± 2		9 ± 11	ND
LINDANE	TR	0.4 ± 0.5		7 ± 10	TR
β - BHC	ND	ND		ND	ND
HEPTACHLOR	ND	ND		ND	ND
ALDRIN	ND	ND		ND	ND
HEPTACHLOR EPOXIDE	ND	ND		ND	ND
THIODAN I	ND	ND		ND	ND
THIODAN II	ND	ND		ND	ND
DIELDRIN	ND	0.4 ± 0.90		1 ± 1	TR
ENDRIN	ND	ND		ND	ND
Σ - DDT	16.4 ± 8	3.4 ± 4.2		15 ± 21	TR
χ - CHLORDANE	3.0 ± 1	3.4 ± 2.3		9 ± 5	2 ± 2
γ - CHLORDANE	3.2 ± 2	2.2 ± 1.8		8 ± 9	2 ± 2
MIREX	Not Analyzed			ND	ND

*Lake Ontario Basin

1.3 DATA ON AIR QUALITY AND PRECIPITATION IN THE LAKE ERIE BASIN

Stanley et al. (44) in 1971, detected p,p' - DDT and o,p' DDT at levels of 11.0 and 2.9 ng/m^3 respectively, in air samples at Lake Erie near Buffalo, New York.

Various studies have recently been completed to determine contaminant levels in precipitation. Analyses by the Ontario Ministry of the Environment, showed PCB levels between 0.03 - 0.07 ppb in rainfall samples from Big Creek and Hillman Creek in Essex County, Ontario (45). Table 1.3-1 illustrates the results of analyses by CCIW of rainfall over Lake Erie (46).

Under sponsorship of the PLUARG studies, Acres Consulting Services Ltd. was authorized to carry out scientific investigations of deposition of airborne material in the lower Great Lakes and the Great Lakes drainage basin (47). Figures 1.3-1 to 1.3-4 show the loading contours in $ng/cm^2/day$ for Pb, Ni, Cu and Cd in Lake Erie. Two sets of loading estimates for various parameters are given in Table 1.3-2, one set based on a mathematical model and the other set, from existing precipitation chemistry data.

Two other PLUARG sponsored studies also evaluated the levels of various contaminants in rainwater from the Lake Erie Basin (170,172). The results are shown in Tables 1.3-3 to 1.3-5, with AG-4 and AG-13 implying the counties of Wellington and Essex.

In the U.S., each state bordering Lake Erie monitors air quality to evaluate compliance with national primary ambient air quality standards for suspended particulates, sulfur dioxide, nitrogen dioxide and carbon monoxide. Annual reports are published by the Michigan Department of Natural Resources Air Quality Division and the Ohio EPA Office of Air Pollution Control. New York maintains an air emission inventory for industrial process emissions, such as for example, aliphatic halogen compounds. The New York program is described the 1977 Appendix E entitled "Status Report on the Persistent Toxic Pollutants in the Lake Ontario Basin" (73) and in the Annual Reports of the New York State Department of Environmental Conservation's Division of Air Resources.

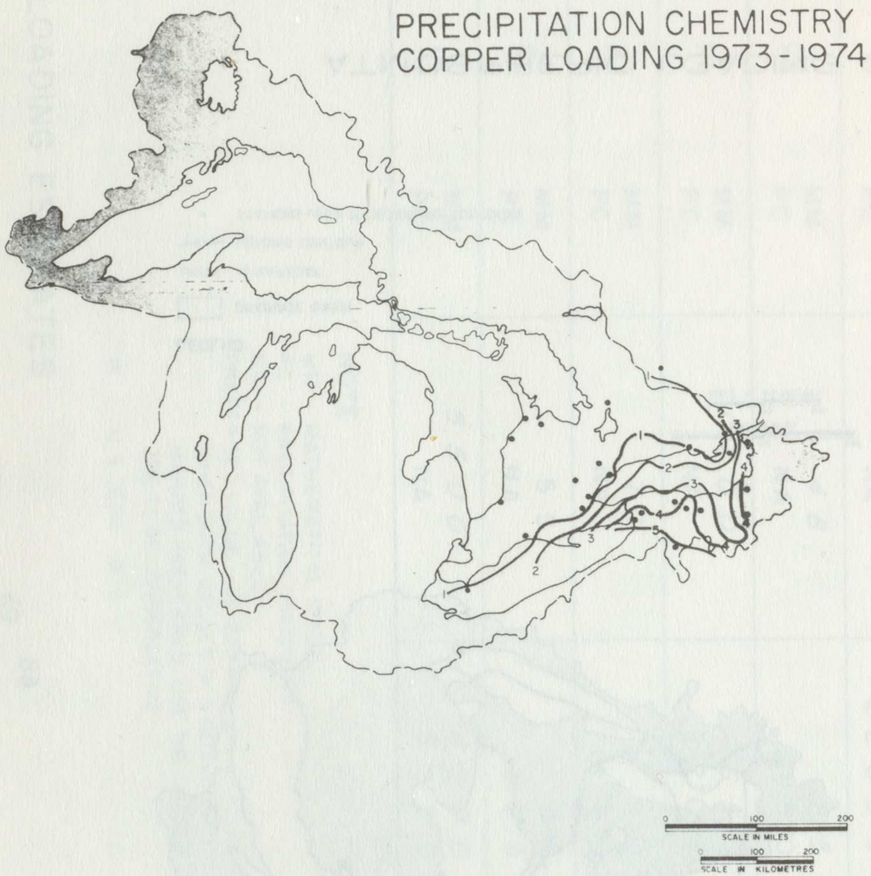
TABLE 1.3-1

ANALYSES OF RAINWATER - LAKE ERIE
(Seven Samples)
1976-77
(Ref. 46)

Parameter	Concentration (ng/ℓ)
Total PCB	9
Lindane	6.1
αBHC	10.3
ΣDDT-Residues	3.8
αEndosulfan	1.6
βEndosulfan	2.0
Dieldrin	2.6
Methoxychlor	13.1
HCB	0.0

Fig. 1.3-3

PRECIPITATION CHEMISTRY
COPPER LOADING 1973-1974



LEGEND

DRAINAGE BASIN

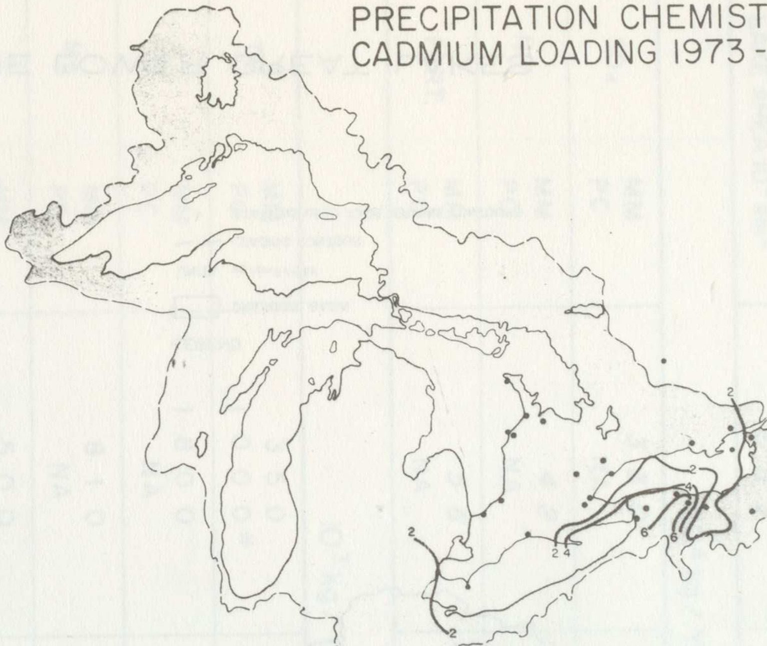
UNITS ng/cm^2/DAY

—1— LOADING CONTOUR

• STATIONS USED TO DETERMINE CONTOURS

Fig. 1.3-4

PRECIPITATION CHEMISTRY
CADMIUM LOADING 1973-1974



LEGEND

DRAINAGE BASIN

UNITS ng/cm^2/DAY

—2— LOADING CONTOUR

• STATIONS USED TO DETERMINE CONTOURS

ATMOSPHERIC LOADING OF THE LOWER GREAT LAKES

Fig. 1.3-1

PRECIPITATION CHEMISTRY
LEAD LOADING 1973 - 1974

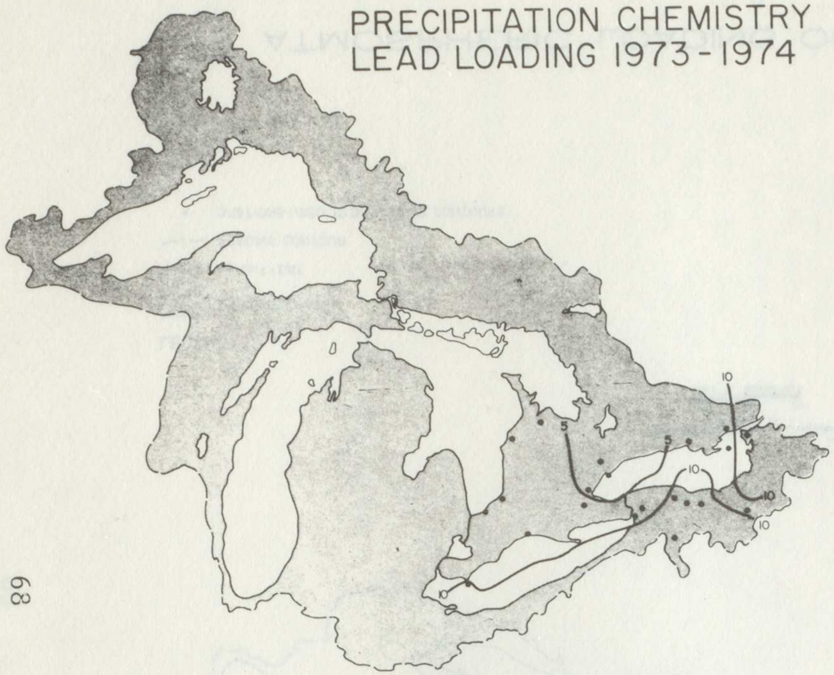
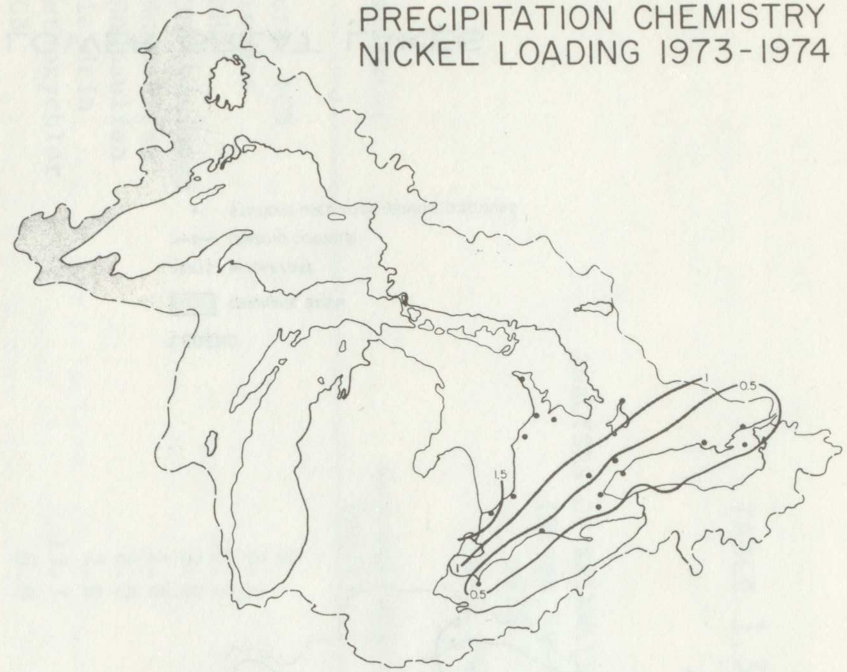
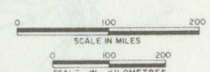


Fig. 1.3-2

PRECIPITATION CHEMISTRY
NICKEL LOADING 1973 - 1974





LEGEND

DRAINAGE BASIN

UNITS ng/cm² / DAY

10 LOADING CONTOUR

• STATIONS USED TO DETERMINE CONTOURS

LEGEND

DRAINAGE BASIN

UNITS ng/cm² / DAY

1 LOADING CONTOUR

• STATIONS USED TO DETERMINE CONTOURS

ATMOSPHERIC LOADING OF THE LOWER GREAT LAKES

TABLE 1.3-2

PARAMETERS		LAKE MICHIGAN	LAKE ERIE	LAKE ONTARIO
LAKE AREA $10^3 \, km^2$		58.2	25.8	19.5
		10^6 kg / YEAR		
SO_4	MM	*330*	*270*	*120*
	PC	NA	*120*	*88*
N	MM	*42*	*29*	*14*
	PC	NA	*19*	*21*
PART.	MM	*56*	*41*	*21*
	PC	NA	NA	NA
		10^3 kg / YEAR		
TP	MM	350	190	110
	PC	1000*	800	480
Ca	MM	1800	1200	620
	PC	NA	23000	32000
Mg	MM	810	550	290
	PC	NA	6600	4100
Na	MM	500	370	190
	PC	NA	13000	19000
K	MM	1500	1100	550
	PC	NA	22000	3300
Cd	MM	*48*	*25*	*18*
	PC	NA	150	*45*
Pb	MM	*1100*	*650*	*440*
	PC	NA	2200	*280*
Ni	MM	71	50	51
	PC	NA	140	*19*
Cu	MM	55	32	21
	PC	NA	330	*72*
Fe	MM	*5500*	*4300*	*2100*
	PC	NA	5900	530

NOTE

MM - MATHEMATICAL MODEL

PC - PRECIPITATION CHEMISTRY

NA - NOT AVAILABLE

PREFERRED VALUE - eg *220*

WHEN BOTH VALUES OF A PAIR ARE MARKED PREFERRED, USE THE LARGER ONE TO BE CONSERVATIVE

* U.S. EPA 1975

LOADING ESTIMATES

Table 1.3-3 Contaminants found in rainwater collected between May to December 1975 in six agricultural watersheds (170)

Component		Content in Rainwater (ng/L)						
		AG-1	AG-3	AG-4	AG-5	AG-10	AG-13	Mean
p,p-DDT	May-June	4	ND	8	1	3	7	4
	June-July	3	2	11	2	7	4	5
	Aug-Sept	5	8	5	7	5	4	6
	Dec.	ND	13	4	NA[1]	19	16	10
Hept.Epox.	Dec.	<1	ND	7	NA[1]	ND	ND	1
PCB	May-June	60	40	10	50	20	30	35
	June-July	50	50	50	ND	80	60	48
	Aug-Sept	50	100	70	100	50	70	73
	Dec.	20	10	30	NA[1]	80	90	46
Leptophos	May-June	1100	ND	ND	ND	ND	ND	

[1] NA - not analysed

Table 1.3-4
(172)

Heavy Metals (mg/l)

Collection Period	AG 1	AG 3	AG 4	AG 5	AG 10	AG 13	AG 1*	AG 13*
Nickel								
4/76-5/76	.003	<.002	.007	<.002	<.002	.002		
7/76-8/76	.300	<.002	<.002	<.002	<.002	.003		
Zinc								
4/76-5/76	.096	.076	.760	.041	.160	.057		
5/76-6/76	.063	.044	.340	.130	.072	.045		
7/76-8/76	.030	.025	.110	.160	.092	.062		
4/77-5/77	.096	.068	-	.040	.072	.032	.190	.071
Lead								
4/76-5/76	.027	.016	.009	.008	<.002	.018		
5/76-6/76	.036	.025	.002	.010	.016	.032		
7/76-8/76	<.002	.004	.004	.007	.014	.010		
4/77-5/77	<.002	.004	-	<.002	<.002	<.002	.025	.008
Cadmium								
4/76-5/76	<.001	<.001	.007	<.001	<.001	<.001		
5/76-6/76	<.001	<.001	.002	.001	.001	.002		
7/76-8/76	<.01	<.001	.001	.001	<.001	<.001		
4/77-5/77	.002	.003	-	.002	.007	.001	.031	.060
Copper								
4/76-5/76	.016	.008	.017	.002	.002	.011		
5/76-6/76	.007	.009	.003	.004	.005	.007		
7/76-8/76	.030	.009	.012	.014	.006	.028		
4/77-5/77	<.001	<.001	-	<.001	<.001	<.001	.024	<.001
Chromium								
4/76-5/76	.003	<.002	.002	<.002	<.002	<.002		
7/76-8/76	.06	<.002	<.002	<.002	<.002	<.002		
Arsenic								
4/76-5/76	.002	.001	.003	<.001	<.001	.007		

* Precipitation-only sample   - No sample

Table 1.3-5

(172)

P.C.B.s (ppb)

Collection Period	AG 1	AG 3	AG 4	AG 5	AG 10	AG 13	AG 1*	AG 13*
5/75-6/75	0.06	0.04	0.05	0.01	0.02	0.03		
7/75-9/75	0.05	0.10	0.10	0.07	0.05	0.07		
11/75-12/75	0.02	0.10	0.03	-	0.08	0.09		
2/76-3/76	ND	-	0.01	ND	-	ND		
7/76-8/76	0.27					0.11	-	0.12
8/76-9/76	0.13					0.32	0.15	0.11
10/76-11/76	0.09					0.15	0.10	0.07

* Precipitation-only sample

\- No sample

1.4 DATA ON MUNICIPAL AND INDUSTRIAL DISCHARGES AND SLUDGES

In 1973, extensive analyses were made for organic contaminants in influents, effluents and sludges at wastewater treatment plants in Monroe and Trenton (48). The results of the analyses are shown in Table 1.4-1 and 1.4-2. One objective of the study was to determine the efficiency of removal of organic contaminants during the wastewater treatment process. Phthalate esters were observed in high concentrations in influents, effluents and sludges.

Analyses for heavy metals in municipal and industrial discharges to Lake Erie are shown in Tables 1.4-3 and 1.4-4 (49, 50). The results of analyses for heavy metals in 3 sewage sludges are shown in Table 1.4-5 (51).

TABLE 1.4-1

MUNICIPAL EFFLUENT ANALYSES - LAKE ERIE BASIN
ORGANIC ANALYSES

MONROE WASTEWATER TREATMENT PLANT

PARAMETER	DATE (1973)	RAW WASTE #1 (µg/L)	RAW WASTE #1 (lbs/day)	RAW WASTE #2 (µg/L)	RAW WASTE #2 (lbs/day)	EFFLUENT (µg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY
Lindane	10/23	0.007	.0003	0.003	.0003	0.009	.001	0.001
	10/24							0.006
								0.002
Heptachlor	10/23	0.008	.0004	<.001	<.00009	0.011	.002	<.001
								0.003
								<.001
Aldrin	10/23	0.090	.004	0.006	.0006	0.030	.004	0.010
	10/24							0.008
	10/25							0.014
Heptachlor Epoxide	10/23	<.001	<.00004	<.001	<.00009	0.004	.0006	0.004
	10/24							0.010
	10/25							<.001
Dieldrin	10/23	0.001	.00004	0.040	.004	0.042	.006	0.049
	10/24							0.003
	10/25							0.009
Endrin	10/23	0.002	.00009	0.020	.002	0.016	.002	<.001
	10/24							<.001
	10/25							<.001
O,P-DDT	10/23	<.001	<.00004	<.001	<.00009	<.001	<.0001	0.010
	10/24							0.014
	10/25							0.020
P,P-DDT	10/23	<.001	<.00004	<.001	<.00009	<.001	<.0001	<.001
	10/24							<.001
	10/25							<.001
O,P-DDD	10/23	<.001	<.00004	<.001	<.00009	0.014	.002	0.004
	10/24							0.004
	10/25							0.008
P,P-DDD	10/23	<.001	<.00004	<.001	<.00009	0.012	.002	0.016
	10/24							0.021
	10/25							0.024
O,P-DDE	10/23	<.001	<.00004	0.010	.0009	0.003	.0004	<.001
	10/24							0.019
	10/25							<.001

TABLE 1.4-1 CONT'D

PARAMETER	DATE (1973)	SAMPLING LOCATIONS: RAW WASTE #1 (µg/L)	RAW WASTE #1 (lbs/day)	RAW WASTE #2 (µg/L)	RAW WASTE #2 (lbs/day)	EFFLUENT (µg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY
P,P-DDE	10/23	0.130	.006	0.070	.007	0.045	.006	0.004
	10/24							<.001
	10/25							0.011
Methoxychlor	10/23	<.001	<.00004	<.001	<.00009	<.001	<.0001	<.001
	10/24							<.001
	10/25							<.001
Di-n-Butyl Phthalate	10/23	80	3.6	170	16.0	65	9.0	13.0
	10/24							11.0
	10/25							56.0
Di-2-ethyl Phthalate	10/23	31	1.4	190	17.9	150	20.9	19.0
	10/24							17.0
	10/25							19.0
Chlordane	10/23	<.001	<.00004	0.480	.045	0.240	.033	0.110
	10/24							0.230
	10/25							0.280
Aroclor 1221, 1232, 1248, 1260, 1262, 1268 (analyses for each individual component)	10/23	<.001	<.00004	<.001	<.00009	<.001	<.0001	<.001
	10/24							<.001
	10/25							<.001
Aroclor 1242	10/23	<.001	<.00004	<.001	<.00009	<.001	<.0001	2.1
								1.6
								1.2
Aroclor 1254	10/23	1.3	.058	0.8	.08	0.8	.11	2.5
	10/24							1.2
	10/25							2.1

TABLE 1.4-2

MUNICIPAL EFFLUENT ANALYSES - LAKE ERIE BASIN

ORGANIC ANALYSES

TRENTON WASTEWATER TREATMENT PLANT

PARAMETER	DATE (1973)	SAMPLING LOCATIONS RAW WASTE (µg/L)	(lbs/day)	EFFLUENT (µg/L)	(lbs/day)	SLUDGE (mg/kg) DRY
Lindane	10/23	.007	.0003	<.001	<.00004	.002
	10/24					<.001
	10/25					.014
Heptachlor	10/23	.011	.0005	.035	.0014	<.001
	10/24					.004
	10/25					<.001
Aldrin	10/23	.066	.003	.040	.002	.002
	10/24					.012
	10/25					.014
Heptachlor epoxide	10/23	<.001	<.00004	<.001	<.00004	<.001
	10/24					.001
	10/25					.020
Dieldrin	10/23	.001	.00004	.004	.0002	.026
	10/24					.014
	10/25					.018
Endrin	10/23	.001	.00004	.006	.0002	.020
	10/24					.008
	10/25					.011
O,P-DDT	10/23	<.001	<.00004	<.001	<.00004	.016
	10/24					.008
	10/25					.064
P,P-DDT	10/23	<.001	<.00004	<.001	<.00004	<.001
	10/24					.004
	10/25					.029
O,P-DDD	10/23	.028	.0011	.005	.0002	.050
	10/24					.011
	10/25					<.001
P,P-DDD	10/23	.010	.0004	.016	.0007	.089
	10/24					.013
	10/25					.084
O,P-DDE	10/23	<.001	<.00004	.022	<.0009	<.001
	10/24					<.001
	10/25					.035

TABLE 1.4-2 CONT'D

PARAMETER	DATE (1973)	SAMPLING LOCATIONS: RAW WASTE (µg/L)	RAW WASTE (lbs/day)	EFFLUENT (µg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY
P,P-DDE	10/23	.069	.003	.103	.004	<.001
	10/24					.010
	10/25					.027
Methoxychlor	10/23	.025	.001	.165	.007	<.001
	10/24					<.001
	10/25					<.001
Di-N-Butyl phthalate	10/23	12	.49	34	1.4	45
	10/24					13
	10/25					18
Di-2-ethyl phthalate	10/23	200	8	17	.70	<50
	10/24					<50
	10/25					3
Chlordane	10/23	1.500	.062	1.100	.045	.920
	10/24					.110
	10/25					.095
Aroclor 1221, 1232, 1260, 1262, 1268 (Analyses for each different component)	10/23	<.001	<.00004	<.001	<.00004	<.001
	10/24					<.001
	10/25					<.001
Aroclor 1242	10/23	<.001	<.00004	<.001	<.00004	2.2
	10/24					3.8
	10/25					3.4
Aroclor 1254	10/23	.9	.04	.3	.01	4.8
	10/24					13.5
	10/25					2.6

TABLE 1.4-3

MUNICIPAL EFFLUENT ANALYSES - LAKE ERIE BASIN

HEAVY METAL CONCENTRATION (μG/L)

SAMPLING DATE	LOCATION MUNICIPAL PLANT	AVERAGE FLOW (MGD)	CADMIUM	CHROMIUM	COPPER	LEAD	ARSENIC	NICKEL	SELENIUM	ZINC	MERCURY	INFORMATION SOURCE
	Ohio											
Jan. 1975	Mentor	4.6	<10	<10	15	<50	<2	<30		39		49
Jan. 1975	Sandusky	15.8	<10	<10	<10	<50		<30		40	<0.2	
Jan. 1975	Avon Lake	3.99	<10	30	30	<50	<2	80		73	<0.2	
Sept.1975		4.04	<10	44	41	110	<5	59		85		
Sept.1975		3.89	<10	35	40	86	<5	54		60	0.3	
Jan. 1975	Medina County	2.69	<8	<10	50	20						
Jan. 1975	Middleburg Hts.	1.03	<8	<10	<10	<10		<30		30	<0.2	
Feb. 1975	Fremont	3.99	<10	<20	<10	<30		<30		100	<0.2	
May 1975	Bedford	2.48	<10	69	140	920		49		130	0.3	
Sept.1975	Perrysburg	1.16	<10	<20	<10	<40					0.2	
Sept.1975	Toledo	93.9	<10	<20	10	<40	<5		<5	77	<0.1	
Sept.1975	Defiance	3.0	12	80	54	<40		300		450	0.5	
Jan. 1976	Bowling Green	5.46	<10	18	12	<60		<75		43	0.4	
Feb. 1976	Conneaut	2.0	<10	<5	<5	<30				63	<0.1	
June 15-16, 1976	Easterly	118	I-124	I-460	I-139	I-222		I-289		I-477	I-0.4	
			E- 18	E- 68	E- 25	E- 37		E-182		E-193	E-0.1	
June 16-17, 1976			I- 70	I-347	I-166	I-260		I-249		I-564	I-0.2	
			E- 18	E- 66	E- 26	E- 34		E-169		E-270	E-0.1	
June 1976	Rocky River	7.5	I-<12	I-104	I- 62	I-<29		I-<23		I-3850	I-0.2	
			E-<12	E- 33	E- 24	E-<29		E-<23		E-1400	E-0.1	
June 1976	Lakewood	13	I-<12	I- 24	I- 62	I-<29		I-<23		I-442	I-0.6	
			E-<12	E- 14	E- 25	E-<29		E-<23		E-128	E-0.2	
	Michigan											
Jan. 1975	Monroe		<10	<10	11	<10	<2	70		64	<0.2	

I - Influent
E - Effluent

TABLE 1.4-4

EPA REGION V - ANALYSES OF WASTEWATER

DISCHARGES TO LAKE ERIE 1975-76

Point Source Discharges	Parameter
	Mercury Levels > .5 μg/L
Harshaw Chem. Co., Black River Elyria, Ohio	11.0 μg/L
Harshaw Chem. Co., overflow	0.8 μg/L
	Cadmium Levels > 150 μg/L
Harshaw Chem. Co., Black River Elyria, Ohio	480-840 μg/L
	Lead Levels > 100 μg/L
Harshaw Chem. Co., Black River Elyria, Ohio	180-2,200 μg/L
Ft. Wayne WWTP Outfall, Maumee River, IN	190 μg/L
Avon Lake STP, Ohio	110 μg/L

TABLE 1.4-5

SEWAGE SLUDGE ANALYSES - LAKE ERIE BASIN

SAMPLING DATE	LOCATION	CONCENTRATION mg/kg dry weight						INFORMATION SOURCE
		CADMIUM	CHROMIUM	COPPER	LEAD	NICKEL	ZINC	
January 1976	Bowling Green, Ohio	16	83	256	345	0.075	677	51
June 1976	Lakewood, Ohio	28	287	516	474	56	2,130	
June 1976	Rocky River, Ohio	0.01	614	391	218	39	10,200	

1.5 DATA ON BENTHOS AND PLANKTON

There does not appear to be much data on contaminant levels in Lake Erie plankton and benthos. Table 1.5-1 briefly summarizes some of the available data (references 5, 52-55). A PLUARG study (171) evaluated contaminant levels in net plankton and amphipods from the Grand River, which is a major tributary to Lake Erie. The results are shown in Tables 1.5-2 and 1.5-3.

TABLE 1.5-1

PLANKTON AND BENTHIC ANALYSES - LAKE ERIE

Location and Date	Sample, Contaminant and Concentration	Source
Western Lake Erie 1971	Benthos (chironomids) - mercury (See Figure 1.5-1)	52
Sandusky Bay 1972	Chironomid larvae - mercury, 0.48 ppm (range .22-.80) in presence of sediment containing average of 0.6 ppm Hg	53
Western Lake Erie 1973-74	Zooplankton - Selenium, 2.54 ± 0.14 ppm dry weight	5
Presque Isle Bay Erie County, PA 1973	Benthos - trace of unidentified Aroclor detected in one of 7 samples. DDT, lindane, dieldrin and heptaclor were not detected.	54
Presque Isle Bay Erie County, PA 1974	Benthos - DDT, lindane, dieldrin and heptachlor all below detection limits. (DDT-.05, lindane-.003, aldrin-.005, dieldrin-.007, heptachlor-.005)[(a)]	55

(a) no units were given in submitted material - assumed to be ppm.

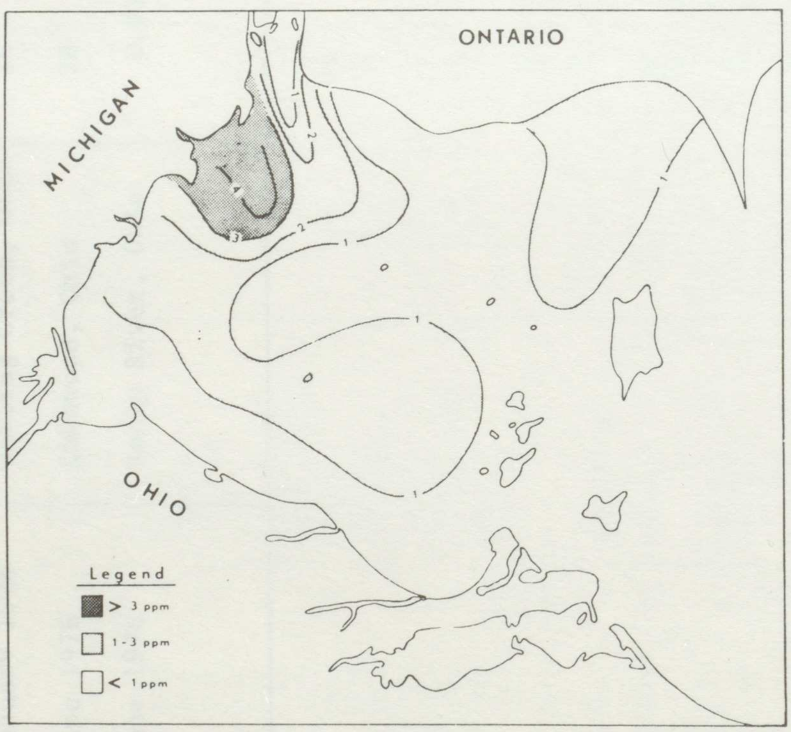


Figure 1.5-1 Mercury concentration in surface sediments of western Lake Erie.

Table 1.5-2

ORGANOCHLORINE CONTAMINANT RESIDUES IN NET PLANKTON FROM OAKVILLE CREEK AND THE GRAND RIVER, 1976 (WET WEIGHT ng/g) ($\bar{x}$ and 96% CONFIDENCE LIMITS).

Chemical	# of Analyses	Oakville Creek	Grand River
PCB	5	21 ± 6	2 ± 4
HCB	5	TR	ND
χ - BHC	5	ND	–
LINDANE	5	ND	–
β - BHC	5	ND	ND
HEPTACHLOR	5	ND	ND
ALDRIN	5	ND	ND
HEPTACHLOR EPOXIDE	5	TR	TR
THIODAN I	5	ND	ND
THIODAN II	5	ND	ND
DIELDRIN	5	1 ± 1	2 ± 1
ENDRIN	5	2 ± 2	–
pp' DDE	5	3 ± 1	
op' DDT	5	TR	ND
pp' DDD	5	2 ± 2	1 ± 2
pp' DDT	5	–	–
χ - CHLORDANE	5	–	2 ± 2
γ - CHLORDANE	5	3 ± 5	3 ± 3
MIREX	5	ND	ND

ND - non detectable

TR - trace

— - less than 1

Table 1.5-3

ORGANOCHLORINE CONTAMINANT RESIDUES IN AMPHIPODS FROM OAKVILLE CREEK AND THE GRAND RIVER, 1976 (WET WEIGHT ng/g). ($\bar{x}$ and 95% CONFIDENCE LIMITS)

Chemical	# of Analyses	Oakville Creek	Grand River
PCB	4	40 ± 8	5 ± 6
HCB	4	5 ± 4	ND
χ - BHC	4	7 ± 1	6 ± 3
LINDANE	4	2 ± 1	1
β - BHC	4	2 ± 0	ND
HEPTACHLOR	4	ND	ND
ALDRIN	4	ND	ND
HEPTACHLOR EPOXIDE	4	ND	ND
THIODAN I	4	ND	ND
THIODAN II	4	ND	ND
DIELDRIN	4	6 ± 1	3 ± 1
ENDRIN	4	ND	ND
pp' DDE	4	25 ± 4	9 ± 2
op' DDT	4	1 ± 1	-
pp' DDD	4	2 ± 1	-
pp' DDT	4	2 ± 1	ND
χ - CHLORDANE	4	2 ± 1	-
γ - CHLORDANE	4	2 ± 1	1 ± 1
MIREX	4	16 ± 5	14 ± 5

ND - non detectable

— - less than 1

1.6 DATA ON FISH CONTAMINANTS

Currently there are several fish contaminant monitoring programs conducted in the nearshore areas of Lake Erie. New York state has a "Statewide Toxic Substance Monitoring Program," within which fish from the vicinity of Lackawanna and Dunkirk are analyzed on an annual basis. The Ont. Min. Env. and Min. of Nat. Res. analyze several species of fish from the Eastern, Western and Central Basins, and from Wheatley and Long Point. Most of the analyses evaluate mercury and PCB concentrations. Within the activities of the Ohio EPA Pesticide Surveillance Program, fish from the Huron and Chagrin Rivers are analyzed for a number of pesticides and other chlorinated compounds. Within the state of Michigan, there is a joint effort between the Michigan Department of Natural Resources, Michigan Department of Agriculture, Michigan Department of Public Health, U.S. Food and Drug Administration (Detroit Office) and the U.S. Fish and Wildlife Service (Ann Arbor Laboratory)to evaluate whether the contaminant levels in fish that are being utilized by the public are in excess of recommended maximum U.S. FDA levels. This program is called the GLECS (Great Lakes Environmental Contaminant Survey) Program. Within the jurisdictions of Michigan, Ohio and Pennsylvania, the U.S. Fish and Wildlife Service has a National Pesticide Monitoring Program underway. The results of many of the above programs are summarized in this chapter.

Heavy Metals

Table 1.6-1 summarizes the mercury concentrations found in Lake Erie fish tissue, particularly from 1969 to 1977 (Ref. 9,15,24,56,57, 58). In 1970 (59) it was found that mercury concentrations were generally higher in western basin fish than in fish from the eastern basin (Table 1.6-2). Studies by the Ontario Ministry of the Environment show that mercury levels are declining in Lake Erie fish tissue (24). Table 1.6-3 and Figures 1.6-1 and 1.6-2 illustrate the observed declines in mercury concentrations in tissue of walleye and white bass.

Concentrations of other heavy metals in Lake Erie fish tissue are shown in Table 1.6-4 (references 9,27,60,61) and Table 1.6-5(5) and Table 1.6-11 (171).

Organic Compounds

Considerable data are available on PCB concentrations in Lake Erie fish tissue, as shown in Table 1.6-6 (references 16,62-67). Data on pesticide residues which are summarized in Tables 1.6-7, 1.6-8 and 1.6-9, were obtained from references 62-69. Herdendorf et al (67) attempted to determine contaminant trends in Lake Erie by evaluating fish residue data within various areas of Lake Erie. DDT and dieldrin levels appear to be decreasing. For PCBs however, some decreasing trends were evident and in other cases, increasing trends were noted. Herdendorf et al noted that "differences in species and size sampled, tissues analyzed and collection data make any comparison between data difficult and unreliable."

Differences in sample preparation do exist among agencies, and trend analysis will be meaningful only if standardized procedures are adopted. For example, a filet may imply: tissue with skin removed; tissue with skin attached; or tissue from a specific portion of the fish. Whole fish analyses may imply: the whole fish; or the whole fish minus the head, tail and gutted.

More detailed analyses of fish from Ashtabula River were made by the Environmental Research Laboratory in Duluth (70). At least 19 compounds and isomers were identified and these are listed in Table 1.6-10.

Tables 1.6-12 - 1.6-14 show the results of a recent PLUARG study of organochlorine residues in shiners from several Lake Erie tributaries (171).

TABLE 1.6-1

MERCURY CONCENTRATIONS IN LAKE ERIE FISH TISSUE

Year	Location	Species	No. Samples	Mean Length (mm)	Mean Weight (gm)	% Lipid	Portion Analyzed (a)	Mean Hg Conc. (ppm)	Source
1967-68	Lake Erie	Brown Bullhead					F	0.19±.03 (.12-.26)	56
		Carp					F	.22±.08 (.07-.30)	56
		Drum					F	.35±.04 (.19-.40)	56
		Gizzard Shad					F	.14±.04 (.05-.25)	56
		Gold fish					F	.13±.06 (.01-.20)	56
		Walleye					F	.84	56
		White Bass					F	.40±.03 (.38-.43)	56
		Yellow Perch					F	.42±.05 (.29-.61)	56
Dec. '69	Wheatley	Yellow Perch	500#				W	0.25	57
Nov. '69	Erie	Coho Salmon	600#				W	0.36	57
1970	Western, Central and Eastern Basins (see Table 1.6-2)								
Mar. '70	Bono	Carp	10	622	4050		F	0.28	57
Mar. '70	Bono	White Bass	15	260	246		F	0.80	57
Mar. '70	Bono	Yellow Perch	13	215	136		F	0.44	57
Mar. '70	Sandusky	Carp	15	546	2838		F	0.08	57
Mar. '70	Sandusky	Yellow Perch	16	186	186		F	0.32	57
Mar. '70	Sandusky	Coho Salmon	14	434	840		F	0.24	57
Mar. '70	Sandusky	White Bass	15	297	400		F	0.80	57
Mar. '70	Sandusky	Channel Catfish	13	388	604		F	0.32	57
Mar. '70	Sandusky	Sheepshead	15	378	708		F	0.24	57
Mar. '70	Sandusky	Gizzard Shad	15	340	472		F	0.24	57
Apr. '70	Monroe	Yellow Perch	10	212	132		F	1.7	57
Mar. '70	Bono	Coho Salmon	12	442	894		F	0.96	57
Apr. '70	Monroe	Coho Salmon	4	467	1126		F	0.96	57
Apr. '70	Bono	Channel Catfish	10	376	454		F	1.8	57
Apr. '70	Monroe	Channel Catfish	10	363	445		F	1.3	57
Apr. '70	Monroe	Walleye	19	454	1050		F	3.6	57
Apr. '70	Monroe	Steelhead	2	454	922		F	<0.15	57
Apr. '70	Sandusky	Walleye	10	472	1258		F	2.60	57
Apr. '70	Raisin Pt.	Walleye	3				F	3.57	
Apr. '70	Raisin Pt.	White Bass	10				F	0.53	57
1971-1977	Lake Erie	Walleye and White Bass (see Table 1.6-3 and Figures 1.6-1 and 1.6-2)							24
1972	Presque Isle	White Bass	9	250	280			0.34 (.20-.42)	15
1972	Presque Isle	Perch	6	230	196			0.25 (.19-.31)	15
1972	Presque Isle	Walleye Pike	6	375	616			0.37 (.31-.41)	15

(a) F: fillet
W: whole fish

TABLE 1.6-2

MERCURY CONTENT IN EDIBLE TISSUE OF LAKE ERIE FISHES

(Ref. 59)

Species	Fall 1970 Basin Western		Central		Eastern		
Walleye	0.79	(25)[a]	0.65	(25)	0.33	(25)	Hg (ppm)
Coho salmon	0.69	(20)	0.58	(10)	0.51	(13)	
Yellow perch	0.61	(25)	0.49	(25)	0.29	(25)	
White bass	0.60	(25)	0.72	(25)	0.43	(25)	
Channel catfish	0.36	(25)	0.42	(20)	-		
Freshwater drum	0.67	(25)	0.62	(20)	0.30	(25)	
Carp	0.23	(25)	0.35	(17)	0.36	(14)	
White sucker	0.55	(24)	0.56	(8)	0.35	(25)	
Gizzard shad	0.20	(25)	0.21	(15)	0.26	(18)	
Smallmouth bass	-		0.55	(14)	-		
Smelt[b]	-		-		0.30	(10)	

a - Numbers in parentheses refer to number of fish used in composite.

b - Mercury content of the entire fish.

TABLE 1.6-3

MERCURY LEVELS IN LAKE ERIE FISH TISSUE

(Ref. 24)

(a) Walleye

Year	N	Mean ppm	Range ppm	% over 0.5 ppm	Mean Length (cm)	Mean Weight (gm)
1971	7	0.55	0.4-0.94	57	26	148
1972	101	0.58	0.14-1.35	76	34	426
1974	50	0.52	0.20-1.06	48	40	831
1975	72	0.68	0.15-1.98	51	45	NA
1976	192	0.31	0.09-1.25	8	35	447
1977	-	-	-	-	-	-

(b) White Bass

Year	N	Mean ppm	Range ppm	% over 0.5 ppm	Mean Length (cm)	Mean Weight (gm)
1971	12	1.19	0.49-2.12	92	20	178
1972	149	0.53	0.08-1.96	34	24	200
1974	-	-	-	-	-	-
1975	61	0.77	0.12-1.57	85	31	457
1976	2	0.31	0.26-0.37	-	28	380
1977	92	0.21	0.06-1.06	5	28	316

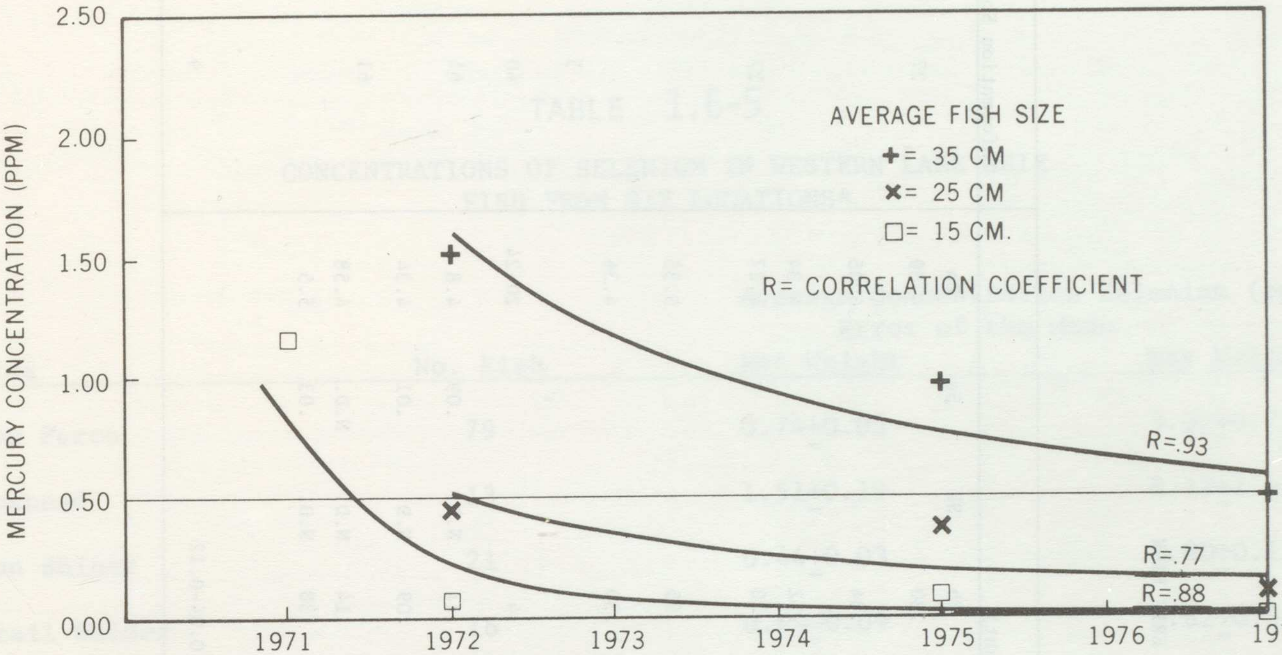


Fig. 1.6-1 DECLINING MERCURY LEVELS IN WHITE BASS FROM WESTERN LAKE ERIE

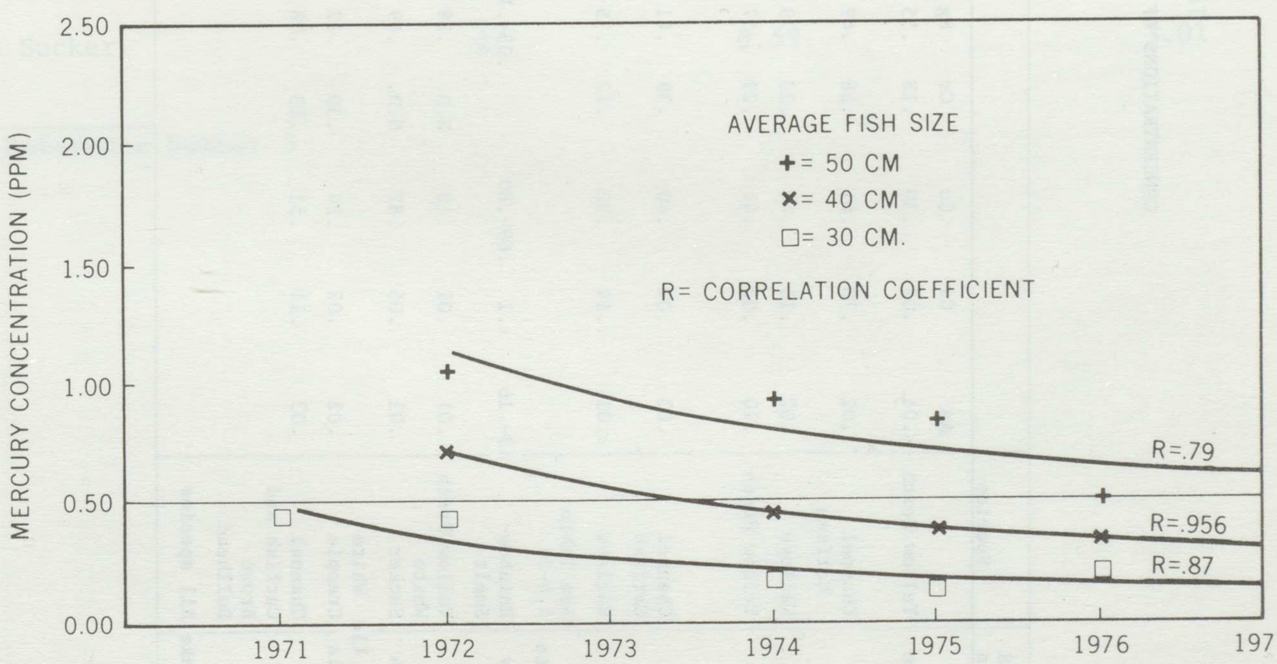


Fig. 1.6-2 DECLINING MERCURY LEVELS IN YELLOW PICKEREL FROM WESTERN LAKE ERIE.

(Ref. 24)

TABLE 1.6-4

CONCENTRATIONS OF HEAVY METALS IN LAKE ERIE FISH

Date	Sampling Location	Species	Metals (ppm wet weight)											Information Source
			As	Cd	Cu	Cr	Hg	Mo	Ni	Pb	Sb	Se	Zn	
1973	Off Swan Creek	Yellow Perch	<.01	.02	.30	.18	.55		.20	.30			4.59	27
		Channel Catfish	.02	.78	.61	.18	.49		.12	.34			6.05	
		Walleye	.02	.10	.44	.20	.79		.13	.52			4.34	
1973	Whiting Power Plant	Yellow Perch	.10	.02	.41	.29	.57		.20	.20			4.27	27
		Channel Catfish	.03	.02	.40	.39	.41		.23	.25			5.35	
		Walleye	<.01	.14	.32	.12	.35		.20	.30			4.36	
1973-74	Western Lake Erie	(See Table 1.6-5)												5
1976	Wheatley Dock	Rainbow Smelt	.13-.16	<.1	.69-.80		.03-.15			<4			20-24	60
1976	Outer Harbor, Erie, PA	Yellow Perch	.01	.01	.18	N.D.	.28	.01	7.53	.14	N.D.	.09	4.8	61
		White Sucker	.01	.05	.82	N.D.	.09	.01	1.91	.09	N.D.	.01	4.34	
1976	Presque Ile Peninsula	White Crappie	.02	.07	.24	.30	.12	.06	.68	.14	N.D.	N.D.	4.58	61
		Channel Catfish and Brown Bullhead	.03	.11	.51	.13	.08	.01	.41	.38	N.D.	.03	5.5	
1976	Whole lake	All species								0.04-0.12				9

TABLE 1.6-5

CONCENTRATIONS OF SELENIUM IN WESTERN LAKE ERIE FISH FROM SIX LOCATIONS*

Species	No. Fish	Average Concentration Selenium (ppm)±1 Std. Error of the Mean Wet Weight	Dry Weight
Yellow Perch	79	0.74±0.05	3.32±0.22
Sheepshead	13	1.51±0.19	8.12±1.02
Common Shiner	21	0.44±0.03	1.80±0.12
Spottail Shiner	16	0.69±0.09	2.82±0.37
Carp	6	0.82±0.13	3.57±0.55
White Bass	4	0.82±0.13	4.26±0.69
Gizzard Shad	4	0.73±0.07	5.69±0.34
Walleye	7	0.52±0.11	2.44±0.52
White Sucker	2	0.59	3.01

*See Reference Number 5

TABLE 1.6-6

ANALYSES OF LAKE ERIE FISH TISSUE

PCB ANALYSES

Year	Location	Species	No. Samples	Mean Length (mm)	Mean Weight (gm)	% Lipid	Portion Analyzed (a)	Mean PCB Conc. (ppm)	Source
1969	Erie, Pa.	Yellow Perch	5	-	880	-		2.3	62
1969	Erie, Pa.	White Sucker	3	-	3300			2.5	62
1969	Erie, Pa.	Freshwater Drum	5	-	2420	-		1.9	62
1970-71	Eastern Basin	Coho Salmon	30	-	-	-		2.1	62
								(1.0-4.3)	62
1970-71	Eastern Basin	White Bass	42	-	-	-		2.1	62
								(1.4-3.5)	62
1970-71	Eastern Basin	Yellow Perch	161	-	-			0.8	62
								(0.2-2.4)	62
1970-71	Eastern Basin	Carp	49	-	-	-		2.0	62
								(0.3-5.3)	62
1970-71	Eastern Basin	Channel Catfish	49		-	-		4.4	62
								(1.4-7.8)	62
1970-71	Eastern Basin	Freshwater Drum	49		-	-		1.1	62
								(0.6-1.5)	62
1971	Western Basin	Salmon	3	-	806	-		1.7	62
1971	Western Basin	Walleye	4	-	460			1.0	62
1971	Western Basin	Rock Bass	1	-	101	-		0.62	62
1971	Western Basin	White Bass	10	-	230	-		2.2	62
1971	Western Basin	Yellow Perch	10	-	116	-		0.96	62
1971	Western Basin	Alewife	7	-	101	-		3.0	62
1971	Western Basin	Catfish	2	-	518	-		5.0	62
1971	Western Basin	Freshwater Drum	9	-	106	-		1.4	62
1971	Western Basin	Gizzard Shad	6	-	92	-		2.6	62
1971	Central Basin	Rock Bass	8		180			0.33	62
1971	Central Basin	Smallmouth Bass	2		1449			5.6	62
1971	Central Basin	White Bass	11		160			1.6	62
1971	Central Basin	Yellow Perch	10		102			0.34	62
1971	Central Basin	Alewife	1		106			2.1	62
1971	Central Basin	Burbot	1		185			0.3	62
1971	Central Basin	Freshwater Drum	9		407			3.7	62
1971	Central Basin	Gizzard Shad	9		72			3.4	62
1971	Central Basin	Pickerel	5		440			0.94	62
1971	Central Basin	Yellow Perch	29		120			0.65	62
1971	Central Basin	White Bass	31		170			1.5	62
1971	Central Basin	Rock Bass	9		170			0.36	62
1971	Central Basin	Burbot	2		180			0.45	62
1971	Central Basin	Smelt	7		30			1.3	62
1971	Central Basin	Alewife	8		100			2.9	62
1972	Western Basin	White Bass	18		120			5.6	62
1972	Central Basin	Smallmouth Bass	18		292			0.73	62
1972	Central Basin	White Bass	30		161			0.96	62
1972	Central Basin	Yellow Perch	30		98			0.25	62
1972	Long Point Bay	Smallmouth Bass	18		169			0.7	62
								(0.52-0.89)	62
1972	Long Point Bay	White Bass	30		169			1.0	62
								(0.6-1.7)	62
1972	Long Point Bay	Yellow Perch	30		98			0.25	62
								(0.18-0.33)	62
1972	Long Point Bay	White Bass	18		120			5.6	62

(a) F: fillet
EP: "edible portion"
W: whole fish

TABLE 1.6-6 CONT'D

Year	Location	Species	No. Samples	Mean Length (mm)	Mean Weight (gm)	% Lipid	Portion Analyzed	Mean PCB Conc. (ppm)	Source
1973	Central Basin	Smelt	10		30			0.50	62
1975	Point Pelee	Minnow	120					1.0 (0.95-1.8)	62 62
1975	Pt. Colborne	Minnow	70					0.22 (0.05-0.85)	62 62
1975	Pt. Rowan	Minnow	70					0.08 (0.04-0.16)	62 62
1975	Turkey Point	Minnow	60					0.14 (0.10-0.17)	62 62
1975	Pt. Rowan	Spot Tail Shiners	5	65±4		2.1±0.6		0.06±0.03	62
1975	Pt. Pelee	Spot Tail Shiners	5	63±3		1.8±0.2		0.84±0.40	62
1975	Pt. Colborne	Spot Tail Shiners	5	61±3		1.2±0.3		0.8±0.03	62
1975	Tremblay Creek	Spot Tail Shiners	4	65±5		3.4±1.9		0.28±0.21	62
1976	Central Basin	Freshwater Drum	8			5.52		0.88	63
1976	Central Basin	White Bass	2			8.43		0.1	63
1976	Central Basin	Alewife	22			23.74		0.38	63
1976	Central Basin	Yellow Perch	21			3.32		0.29	63
1976	Western Basin	Freshwater Drum	23			4.42		0.63	63
1976	Western Basin	Yellow Pickerel	11			3.7		0.7	63
1976	Western Basin	Yellow Perch	10			2.1		0.58	63
1976	Western Basin	Coho Salmon	9			2.65		1.4	63
1976	Western Basin	Yellow Perch	31			1.76		0.6	63
1976	Western Basin	Yellow Walleye	2			21.3		4.6	63
1976	Long Point Bay	Smelt	75			2.0		0.32 (0.25-0.95)	62 62
1976	Wheatley Dock	Smelt	75			1.6		0.59 (0.20-0.95)	62 62
1976	Western Basin	White Bass	3		343	7.2		0.26	58
1976	Western Basin	Gizzard Shad	27		138	11.4		0.02	58
1976	Western Basin	E.Shiners	60		85	6.7		0.06	58
1976	Western Basin	Smelt	60		196	3.5		0.06	58
1976	Western Basin	Alewife	21		43	8.5		0.02	58
1976	Western Basin	Spotted Tail Shiners	60		223	3.8		0.05	58
1976	Whole lake	All species	3000					0.03-1.52	9
1976	Erie, Pa.	Yellow Perch	5				F	0.23	16
1976	Erie, Pa.	White Sucker	5				F	0.05	16
1976	Erie, Pa.	White Crappie	5				F	0.19	16
1976	Erie, Pa.	Channel Catfish, Brown bullhead	5				F	0.93	16
1976	Lake Erie	Yellow Perch	4	193			EP	0.18	16
1976	Lake Erie	White Bass	4	213			EP	0.32	16
1976	Lake Erie	Smallmouth Bass	3	287			EP	0.44	16
1976	Lake Erie	Rainbow Trout	1	533			EP	0.34	16
1976	Lake Erie	Walleye	1	368			EP	0.11	16
1976	Lake Erie	Coho Salmon	1	526			EP	0.74	16
1976	Presque Isle Bay	Yellow Perch	2	267			EP	0.33	16
1976	Presque Isle Bay	Walleye	1	358			EP	0.22	16
1976	Presque Isle Bay	White Crappie	1	236			EP	0.38	16
1976	French Creek	Smallmouth Bass	1	241			EP	0.17	16
1976	Godfrey Run	Coho Salmon	6	486			(f)	4.36	16

TABLE 1.6-6 CONT'D

Year	Location	Species	No. Samples	Mean Length (mm)	Mean Weight (gm)	% Lipid	Portion Analyzed	Mean PCB Conc. (ppm)	Source
1976	Tributary to L.Erie	Rainbow Trout	3	517			(f)	3.71	16
1977	Dunkirk	Rainbow Trout	15	523		8.2		1.21 (0.46-2.66)	64 64
1977	Dunkirk	Brown Trout	2	436		11.3		1.57	64
1977	Dunkirk	Coho Salmon	5	445		9.2		0.86 (0.7-0.99)	64 64
1977	Dunkirk	Smallmouth Bass	17	358		3.5		1.3 (0.43-2.31)	64 64
1977	Dunkirk	Yellow Perch	21	245		0.8		0.25 (0.13-0.41)	64 64
1977	Dunkirk	Walleye	21	510		3.8		0.56 (0.13-1.36)	64 64
1977	Athol Springs	Smallmouth Bass	15	370		3.2		0.88 (0.28-1.53)	64
1977 (Apr.-Aug)	Western Basin	Coho Salmon	30		1495	4.0	(f)	0.52 (0.23-0.98)	65 65
1977 Aug.	Central Basin	Coho Salmon	21		640	5.5	(f)	0.51 (0.17-1.2)	65 65
			20		673			0.533	65
1977	Godfrey Run	Rainbow Trout	1	620			EP	0.6[(a)]	66
1977	Godfrey Run	Brown Trout	1	500			F	1.1[(a)]	
1977	Lagoons of Presque Isle Bay	Largemouth bass	1	305				N.D.	66
1977	Maumee River Sandusky Bay David Besse	Shad, perch, carp, drum catfish						See Table 1.6-8	67

(a) Aroclor 1254 concentrations: Aroclor 1248 not detected.

TABLE 1.6-7

PESTICIDE RESIDUES IN LAKE ERIE FISH

Year	Location	Species	No. Samples	Mean Length (mm)	% Lipids	Portion Analyzed	Heptachlor Epoxide	ΣDDT	DDE	TDE	DIELDRIN	ENDRIN	CHLORDANE	MIREX	SOURCE
							Average Concentrations PPM (Ranges in Brackets)								
1974	Port Clinton Ohio	White Bass		280	9.8	W		3.2	2.5	.47	.13				68
		Walleye		440	16.4	W		.98	.43	.49	.14				68
		Carp		353	10.3	W		.21	.06	.15	.03				68
1974	Erie, PA	Freshwater Drum			12.1	W		.10	.10						68
		Yellow Perch			4.5	W		.06	.06						68
		White Sucker			5.8	W		.02	.02						68
1974-75	Pt. Colborne	Spot Tail Shiners	5	61±3	1.2±.3		0.001±.001	.03±.02			N.D.	N.D.	N.D.		62
1975	Pt. Rowan	Spot Tail Shiners	5	65±4	2.1±0.6		.001±.001	.13±.07			N.D.	N.D.	N.D.		62
1975	Pt. Pelee	Spot Tail Shiners	5	63±3	1.8±0.2		ND	.09±.02			N.D.	N.D.	N.D.		62
1975	Trembley Creek	Spot Tail Shiners	4	65±5	3.4±1.9		.002±.001	.08±.05			N.D	N.D.	N.D.		62
1975-76	Wheatley Dock	Smelt	15											N.D.	62
1975-76	Long Point Bay	Smelt	5											N.D.	62
1975-76	Turkey Point	Minnow	6											N.D.	62
1975-76	Point Pelee	Minnow	12											N.D.	62
1975-76	Pt. Rowan	Minnow	6											N.D.	62
1975-76	Pt. Colborne	Minnow	6											N.D.	62
1976	Central Basin	Freshwater Drum	8		5.52			0.11	0.05	0.06	0.05				63
1976	Central Basin	White Bass	2		8.43			0.09	0.03	0.06	0.17				63
1976	Central Basin	Alewife	22		23.7			0.16	0.05	0.10	0.09				63
1976	Central Basin	Yellow Perch	21		2.36			0.06	0.03	0.03	0.03				63
1976	Central Basin	Yellow Perch	9		4.41			0.07	0.03	0.04	0.03				63
1976	Central Basin	Gizzard Shad	7		12.2			0.15	0.05	0.10	0.08				63
1976	Central Basin	Emerald Shiner	60		7.7			0.10	0.04	0.05	0.04				63
1976	Central Basin	Rainbow Smelt	65		3.49			0.06	0.03	0.03	0.03				63
1976	Western Basin	White Bass	3		7.2			0.43	0.20	0.23	0.16				63
1976	Western Basin	Gizzard Shad	27		11.4			0.14	0.05	0.09	0.08				63
1976	Western Basin	Emerald Shiners	60		6.68			0.12	0.06	0.06	0.05				63
1976	Western Basin	Smelt	60		3.48			0.08	0.04	0.04	0.03				63

TABLE 1.6-7 (CONT'D)

PESTICIDE RESIDUES IN LAKE ERIE FISH

Average Concentrations PPM (Ranges in Brackets)

Year	Location	Species	No. Samples	Mean Length (mm)	% Lipids	Portion Analyzed	Heptachlor Epoxide	ΣDDT	DDE	TDE	DIELDRIN	ENDRIN	CHLORDANE	MIREX	SOURCE
1976	Western Basin	Alewife	21		8.49			0.13	0.05	0.08	0.07				63
1976	Western Basin	Spot Tail Shiners	60		3.78			0.11	0.05	0.06	0.06				63
1976	Western Basin	Freshwater Drum	23		4.42			0.07	0.04	0.03	0.03				63
1976	Western Basin	Yellow Pickerel	11		3.70			0.13	0.06	0.06	0.05				63
1976	Western Basin	Yellow Perch	10		4.12			0.10	0.05	0.05	0.05				63
1976	Western Basin	Coho Salmon	9		2.65			0.34	0.24	0.1	0.76				63
1976	Western Basin	Yellow Perch	49		1.76			0.07	0.03	0.04	0.04				63
1976	Western Basin	Yellow Walleye	2		21.3			1.32	0.70	0.50	0.36				63
1976	Ashtabula River	See Table 1.6-10													63
1977 (Spring)	Dunkirk	Rainbow Trout	15	525	8.2			0.13 (0.03-0.19)						0.00	64
1977	Dunkirk	Brown Trout	2	436	11.3			0.17 (0.16-0.19)						0.00	64
1977	Dunkirk	Coho Salmon	5	445	9.2			0.09 (0.07-0.11)						0.00	64
1977	Dunkirk	Smallmouth Bass	17	358	3.5			0.14 (0.06-0.27)						0.00	64
1977	Athol Spring	Smallmouth Bass	15	370	3.2			0.08 (0.03-0.13)						0.00	64
1977	Dunkirk	Yellow Perch	21	245	0.8			0.02 (0.01-0.03)						0.00	64
1977	Dunkirk	Walleye						0.07 (0.02-0.14)						0.00	64
1977	Godfrey Run	Coho Salmon	2	650		F	0	0.15	0.06	0.06	0				66
1977	Godfrey Run	Rainbow Trout	1	610		EP	0	0.18	.06	.08	0				66
1977	Godfrey Run	Brown Trout	1	432		F	0	.30	.14	.11	0				66

TABLE 1.6-7 CONT'D

PESTICIDE RESIDUES IN LAKE ERIE FISH

Average Concentrations PPM
(Ranges in Brackets)

Year	Location	Species	No. Samples	Mean Length (mm)	% Lipids	Portion Analyzed	Heptachlor Epoxide	ΣDDT	DDE	TDE	DIELDRIN	ENDRIN	CHLORDANE	MIREX	SOURCE
1977 (Fall)	Dunkirk	Rainbow Trout[a]	11	512	14.9			0.17 (0.08-0.29)						0.00	66 66
1977	Dunkirk	Brown trout[a]	11	456	8.1			0.16 (0.1-0.29)						0.00	66 66
1977	Dunkirk	Coho Salmon[a]	7	538	5.7			0.11 (0.08-0.17)						0.00	66 66
1977	Western Basin	Coho Salmon												N.D.	65
1977	Central Basin	Coho Salmon	20											N.D.	65
1977	Maumee River	See Table 1.6-8													67
	Lake Erie - David Besse														67
	Sandusky Bay														67

[a] HCB Analyses also performed. Results below detection limit 0.01.

TABLE 1.6-8

PESTICIDE AND PCB RESIDUES IN LAKE ERIE FISH - FALL 1977
(Reference 67)

Sample	LOCATION	SPECIES	TISSUE	NO. FISH	NO. OF ANALYSES	WEIGHT (g)	RESIDUE CONCENTRATIONS (p p m) % LIPID	DDE	DDD	TOTAL DDT	DIELDRIN	ALDRIN	trans-CHLORDANE	cis-CHLORDANE	BHC	HEPTACHLOR EPOXIDE	LINDANE	PCB
1	2	Shad	Whole Body	3	1	14,25,26	8.0	.03	.08	.11	.017	ND	.01	.03	<.01	ND	<.01	.69
2	1	Shad	"	3	1	25,83,170	5.0	.05	.07	.12	.05	ND	.01	.05	<.01	<.01	ND	1.72
4	3	Perch	"	3	1	112,116,130	28	.03	.04	.07	<.01	ND	<.01	.02	<.01	<.01	ND	.44
5	3	Perch	"	3	1	74,103,105	0.7	<.01	.02	.02	<.01	ND	<.01	<.01	<.01	ND	ND	.35
6	3	Carp	"	1	1	616	12	.02	.05	.07	.01	ND	<.01	.02	<.01	ND	ND	.21
7	3	Carp	"	1	1	620	7	.02	.04	.06	.01	ND	<.01	.02	<.01	<.01	ND	.32
9	3	Drum	"	1	1	189.9	6.9	.04	.03	.08	<.01	ND	<.01	.01	<.01	<.01	ND	.26
10	3	Drum	"	1	1	132.3	3.1	.03	.05	.08	.01	ND	<.01	.02	<.01	<.01	ND	.36
12	3	Perch	Filet	1	2	232.1	2.7	.04	.07	.13	<.01	ND	<.01	.03	<.01	<.01	ND	.06
13	3	Perch	Carcass				13	.07	.12	.21	.06	ND	.01	.04	<.01	<.01	ND	1.34
14	3	Perch	Filet	1	2	108	2.8	.05	.09	.14	<.01	.04	<.01	.03	<.01	ND	ND	.69
15	3	Perch	Carcass				4.8	.03	.06	.11	.02	ND	.01	.03	<.01	<.01	ND	.46
16	2	Catfish	Dressed Fish	1	2	599	12.2	.21	.40	.63	.08	ND	.06	.13	.01	.02	ND	3.14
17	2	Catfish	Carcass				8.9	.14	.32	.46	.04	.15	.04	.09	.01	.01	<.01	2.5
18	3	Perch	Carcass	1	2	154.8	11.4	.14	.26	.40	.06	ND	ND	.08	.03	ND	ND	1.63
19	3	Perch	Filet				0.7	<.01	.01	.01	<.01	ND	<.01	<.01	<.01	<.01	ND	T
20	3	Catfish	Dressed Fish	1	2	331.8	7.1	.14	.17	.33	.02	ND	ND	.05	<.01	<.01	ND	3.85
21	3	Catfish	Carcass				6.1	.19	.18	.39	<.01	ND	.03	.07	.01	<.01	ND	2.76
22	3	Catfish	Dressed Fish	1	2	294	15.4	.22	.33	.55	.17	.26	.04	.14	.02	ND	ND	3.33
23	3	Catfish	Carcass				15.7	.17	.27	.46	.14	.26	.06	.14	.03	.02	ND	3.52

ND - None detected
T - Trace

Location: 1 - MAUMEE RIVER (Toledo Edison Plant at river mouth)
2 - LAKE ERIE-DAVIS BESSE
3 - SANDUSKY BAY (outer bay)

TABLE 1.6-9

SUMMARY OF GLECS* DATA
LAKE ERIE FISH

(Ref. 69)

Date	Site	Species	No.	Concentrations - ppm DDT	PCB	Mercury	Dieldrin
1974	Monroe	Carp <5 lbs	4	.28	3.7	.34	0.0
		Carp >5 lbs.	8	.36±.26	3.9±1.6	.27±.07	.01
1974	Monroe	Catfish >17"	3	.31	2.97	.66	.00
		Catfish 17-20"	2	.43	3.00	.20	.09
1974	Monroe	Drum	10	.01	.52±1.0	.43±.16	.00
1974	Monroe	Yellow Perch	24	.00	.03	.36	.00
1974	Monroe	Walleye	12	.06±.16	.22±.40	.33±.23	.01
1974	Monroe	White Bass	6	.02	2.18±1.22	.63±.14	.01
1975	Monroe	Carp <5 lbs	11	.13±.11	3.17±1.95	.21±.11	.01
		Carp >5 lbs.	1	.24	3.9	.41	.01
1975	Monroe	Catfish >17"	5	.16±.13	3.29±1.85	.23±.09	.02
		Catfish 17-20"	2	.30	5.65	.30	.01
1975	Monroe	Drum	12	.00	.11	.38±.29	.00
1975	Monroe	Salmon	8	.04±.04	.38±.34	.06	.02
1975	Monroe	Walleye	13	.01±.02	.34±.42	.31±.24	.00
1975	Monroe	White Bass <10"	2	.00	.55	.39	.00
		White Bass >10"	6	.02±.03	1.78±1.10	.73±.18	.03±.03
1975	Monroe	Rainbow Trout	1	.04	.70	.00	.01
1975	Monroe	Chinook Salmon	6	.06±.02	.25±.17	.06	.04

* Great Lakes Environmental Contaminant Survey

TABLE 1.6-10

CHLORINATED ORGANICS DETECTED IN TISSUE

OF FISH FROM ASHTABULA RIVER -1976 - ERL - DULUTH

Tetrachlorobenzene I	Tetrachlorobutadiene I, II
Pentachlorobenzene	Pentachlorobutadiene I, II
Hexachlorobenzene	Hexachlorobutadiene
Hexachlorostyrene I, II	Tetrachloropropene
Heptachlorostyrene I, II	Pentachloropropane
Octachlorostyrene	Pentachloronorbornene
Cis- chlordane	Trans-nonachlor
DDE	

Table 1.6-11 HEAVY METAL RESIDUES IN SPOTTAIL SHINERS, 1977 (µg/g) (MEANS AND 95% CONFIDENCE LIMITS)

SITE LOCATION	Sample No	T.L. (mm)	% Lipid	Hg	Cu	Zn	Pb	As
GEORGIAN BAY								
Nottawasaga River	10	58±2	8±0.1	0.035±0.003	-*	-*	-*	-*
LAKE ST. CLAIR								
Thames River (Tremblay Creek)	10	58±2	1.5±0.2	0.062±0.004	-*	-*	-*	-*
LAKE ERIE								
Detroit River (Big Creek)	9	57±2	0.9±0.1	0.093±0.010	1.57±0.3	29±2		0.13±0.008
Sturgeon Creek	10	58±2	1.6±0.2	0.056±0.004	-*	-*	-*	-*
Grand River	10	45±2	1.5±0.1	0.037±0.010	-*	-*	-*	-*
LAKE ONTARIO								
Niagara River	10	51±3	2.9±0.1	0.074±0.008	1.27±0.3	32±4		0.21±0.020
Burlington Beach	9	55±3	5.3±0.5	0.039±0.006	-*	-*	-*	-*
Humber River	10	62±2	7.2±0.3	0.044±0.003	1.22±0.2	26±1		0.09±0.009
Salmon River	10	78±2	3.8±0.2	0.01± 0.004	-*	-*	-*	-*

* not analyzed for

Table 1.6-12

ORGANOCHLORINE CONTAMINANT RESIDUES FOUND IN EMERALD SHINERS IN OAKVILLE CREEK AND THE GRAND RIVER, 1976 (ng/g)
($\bar{x}$ and 95% confidence limits)

LOCATION	No. Samples	Total Length (mm)	% Lipid	PCB	HCB	χBHC	Lindane	βBHC	Heptachlor	Aldrin
LAKE ONTARIO										
Oakville Creek	10	82±3	3.9±0.6	1402±473	12±4	5±4	2±1	1±1	ND	ND
LAKE ERIE										
Grand River	10	81±1	4.3±0.9	554±75	ND	5±2	2±1	ND	ND	ND
Grand River (young-of-the-year)	8	46±0.1	2.6±0.2	146±8	ND	6±2	3±1	-	ND	ND

Continuation of above

LOCATION	Heptachlor Epoxide	Thiodan I & II	Dieldrin	Endrin	pp' DDE	op' DDT	pp' DDD	pp' DDT	χ-Chlordane	γ-Chlordane	Mirex
LAKE ONTARIO											
Oakville Creek	2±1	ND	7±2	2±1	182±73	18±7	28±10	6±3	20±7	19±3	39±8
LAKE ERIE											
Grand River	2±1	ND	14±7	2±1	72±14	15±7	24±6	5±2	11±6	13±6	ND
Grand River (young-of-the-year)	1±0	ND	5±2	-	24±6	4±1	11±2	2±1	3±2	7±2	ND

ND - non detectable

— - Less than 1

Table 1.6-13

ORGANOCHLORINE CONTAMINANT RESIDUES FOUND IN SPOTTAIL SHINERS IN SOME ONTARIO DRAINAGE BASINS, 1977 (ng/g)
($\bar{x}$ and 95% confidence limits)

LOCATION	No. Samples	Total Length (mm)	% Lipid	PCB	ΣDDT	Mirex	HCB	χBHC	Lindane
GEORGIAN BAY									
Nottawasaga River	10	58±2	8.0±0.1	90± 7	106± 7	ND	ND	4±1	ND
LAKE ST CLAIR									
Thames R. (Tremblay Creek)	10	58±2	1.5±0.2	64±11	12± 4	ND	ND	ND	ND
LAKE ERIE									
Detroit River (Big Creek)	9	57±2	0.9±0.1	447±41	71±13	ND	ND	ND	ND
Sturgeon Creek (Pt. Pelee)	10	58±2	1.6±0.2	467±70	133±28	ND	ND	ND	ND
Grand River	10	45±2	1.5±0.1	56± 7	12± 1	ND	ND	ND	ND
LAKE ONTARIO									
Niagara River	10	51±3	2.9±0.1	654±105	150±20	13±2	25±7	8±3	11±5
Burlington Beach	9	55±3	5.3±0.5	833±69	267±24	9±1	4±2	7±1	3±1
Humber River	10	62±2	7.2±0.3	2175±155	276±36	5±1	5±1	38±4	3±1
Salmon River	10	78±2	3.8±0.2	112±20	44±7	1±1	ND	3±1	ND

Continuation of above

LOCATION	βBHC	Heptachlor Epoxide	Dieldrin	Endrin	χChlordane	γChlordane	Heptachlor	Aldrin
GEORGIAN BAY								
Nottawasaga River	ND	3±1	6±3	2±1	8±3	3±2	ND	ND
LAKE ST. CLAIR								
Thames R. (Tremblay Creek)	ND	ND	ND	ND	3±2	ND	ND	ND
LAKE ERIE								
Detroit River (Big Creek)	ND	ND	ND	ND	ND	ND	ND	ND
Sturgeon Creek (Pt. Pelee)	ND	ND	ND	ND	13±3	11±2	ND	ND
Grand River	ND	ND	ND	ND	ND	ND	ND	ND
LAKE ONTARIO								
Niagara River	7±4	1±1	ND	ND	87±8	28±8	ND	ND
Burlington Beach	1±1	3±1	ND	ND	25±6	23±6	ND	ND
Humber River	ND	2±1	18±1	4±1	3±1	57±11	ND	ND
Salmon River	ND	ND	ND	ND	1±1	12±3	ND	ND

ND - non-detectable

Table 1.6-14

ORGANOCHLORINE CONTAMINANT RESIDUES IN ADULT EMERALD SHINERS FROM OAKVILLE CREEK AND GRAND RIVER (1976) COMPARED TO ADULT EMERALD SHINERS FROM NOTTAWASAGA AND SAUGEEN RIVERS (1977), (ng/g) ($\bar{x}$ and 95% confidence limits)

LOCATION	No. of Analyses	Total Length (mm)	% Lipid	PCB	ΣDDT	Mirex	HCB	χBHC	Lindane
Oakville Creek	10	82±3	3.9±0.6	1402±473	235±124	39±8	12±4	5±4	2±1
Grand River	10	81±1	4.3±0.9	554±75	116±20	ND	ND	ND	2±1
Nottawasaga River	10	83±3	10±1	241±72	160±9	ND	ND	7±1	1±1
Saugeen River	10	81±3	6±1	188±23	100±18	ND	ND	2±1	2±2

Continuation of above

LOCATION	βBHC	Heptachlor	Heptachlor Epoxide	Aldrin	Dieldrin	Endrin	χChlordane	γChlordane
Oakville Creek	1±1	ND	2±1	ND	7±2	2±1	20±7	19±3
Grand River	ND	ND	2±1	ND	14±7	2±1	11±6	13±6
Nottawasaga River	ND	ND	3±1	ND	12±5	4±2	3±1	14±2
Saugeen River	ND	ND	1±1	ND	ND	ND	16±5	ND

ND - non-detectable

1.7 DATA ON WILDLIFE

Analyses of herons, starlings and herring gull eggs from the Lake Erie Basin are summarized in Tables 1.7-1 and 1.7-2 (references 71-74). Because most of the analyses are recent, no trends can be determined.

Intensive analyses of residues in fish-eating birds of Lake Erie are currently underway, and preliminary results may be available by July 1979. The program is to continue until March 1980.

TABLE 1.7-1

WILDLIFE ANALYSES - LAKE ERIE

LOCATION	SPECIES	NO. ANALYZED	RESIDUES, ppm wet weight: DDE	TDE	DDD	DDT	DIELDRIN	PCBs	HEPTACHLOR EPOXIDE	BHC	HCB	OXYCHLORDANE	MERCURY	MIREX	PHOTOMIREX	INFORMATION SOURCE
Oak Harbor Port Clinton, Ohio, 1972	Herons	25											(See Table 1.7-2)			71
Wood County Ohio, 1974	Starlings	10	0.025	TR		0.021	0.092	0.13	0.009	TR	0.013	0.008				72
Jefferson County, New York 1974	Starlings	10	0.62	TR		0.01	ND	0.006	0.005	TR	TR	TR				72
Lake Erie 1974 and 1975	Herring Gull Eggs	42	7.04 (3.8-14.3)			0.04 (0.01-0.15)	0.30 (0.10-0.69)	65.8 (41.2-110)	0.14 (0.04-0.28)	-	0.11 (0.06-0.31)	-	0.22 (0.11-0.35)			73
Port Colborne 1975 1977	Herring Gull Eggs	12 10	7.6±1.8 7.4±2.2		.07±.01 .19±.07	.02±.01 .05±.03	.36±.12 .31±.09	52.7±12.6 78.1±23.7 (Aroclor 1254/1260)	.15±.03	.04±.02	.08±.02 .19±.06			.40±.16 .39±.34	 .14±.12	74
Middle Is. 1975 1976	Herring Gull Eggs	10 10	6.9±1.7 7.4±2.2		.02±.01 .19±.07	.03±.02 .05±.02	.28±.17 .31±.09	70.7±13.4 78.1±24.0 (Aroclor 1254/1260)	.11±.05	.04±.02	.12±.05 .19±.07			.22±.06 .39±.34	 .14±.12	74

TABLE 1.7-2

Mercury concentrations (ppm fresh weight) in great blue herons, black-crowned night herons and American egrets collected during August and September 1972 from the southwestern Lake Erie region.

Age Location of collection Species	N	Breast muscle $\bar{X}$	Breast muscle Range	Liver $\bar{X}$	Liver Range	Brain $\bar{X}$	Brain Range	Primary wing feathers $\bar{X}$	Primary wing feathers Range
Adult:									
Winous Point Shooting Club:									
Great blue heron	2	.30	.19-.40	1.16	1.05-1.27	.18	.14-.22	3.15	2.72-3.57
Black-crowned night heron	2	.31	.27-.36	4.38	.67-8.08[1]	.27	.24-.29	5.10	5.10
American egret	3	.66	.65-.68	1.57	1.09-2.46	.42	.38-.47	5.09	3.79-6.00
West Sister Island									
Black-crowned night heron	2	1.12	1.10-1.13	3.13	3.29-2.98	1.14	1.10-1.18	11.53	10.49-12.5
American egret	1	.31	.31	1.05	1.05	.43	.43	4.92	4.92
Juvenile:									
Winous Point Shooting Club:									
Great blue heron	3	.25	.17-.27	1.60	1.30-2.12	.22	.17-.27	3.83	3.42-4.27
West Sister Island:									
Black-crowned night heron	2	.47	.36-.59	1.42	.84-2.00	.44	.26-.62		
Nestling:									
Winous Point Shooting Club:									
Great blue heron	4	.12	.07-.19	.93	.74-1.23	.12	.08-.15		
West Sister Island:									
Great blue heron	2	.62	.56-.69	3.16	1.98-4.34	.28	.24-.31		
Black-crowned night heron	2	.55	.53-.57	1.26	.77-1.76	.32	.20-.45		
American egret	2	.50	.40-.60	.80	.65-.95	.18	.15-.21		

[1]Analysis indicated at least 8.08 ppm Hg. Precise measurement of the Hg concentration beyond this level was not determined.

2 ST. CLAIR RIVER, LAKE ST. CLAIR, DETROIT RIVER BASINS

Annual sampling programs on the Detroit River have occurred consistently since 1967. Specific details of the programs are described in the Surveillance Subcommittee's 1977 report (75) to the Water Quality Board, and the results are reported in the Subcommittee's Annual Reports. Data on the Detroit River prior to 1967, are found in such documents as the: "Proceedings of a Conference in the Matter of Pollution of the Navigable Waters of the Detroit River and Lake Erie and Their Tributaries in the State of Michigan"(3), and the report "Water Pollution Investigation: Detroit and St. Clair Rivers." The latter report (76) reviews historical chemical and biological data, as well as data obtained in 1973. A recent report by the Ont. Min. of Nat. Resources (174) reviews past and existing environmental monitoring programs on Lake St. Clair - St. Clair River.

2.1 DATA ON WATER QUALITY

Tables 2.1-1 and 2.1-2 show the changes in concentrations of metals from the beginning of St. Clair River to the mouth of the Detroit River (76,77). Increases in cadmium, chromium, copper, lead and nickel are observed, especially downstream from the Ecorse River.

Table 2.1-3 lists the organic compounds found during the EPA study to detect previously unrecognized pollutants in surface waters (18) and during the Health and Welfare Canada national survey of halomethanes in drinking water (78). Table 2.1-4 shows the results of the Michigan Department of Natural Resources survey of water quality in the Detroit and St. Clair Rivers (77).

A recently published PLUARG report (170) lists the concentrations of pesticides found in the Big Creek (AG-1) and Holiday Creek (AG-5) watersheds which eventually drain into Lake St. Clair via the Thames River. Table 1.1-11 describes the watershed sizes and tables 1.1-12 to 1.1-22 show the detected concentrations of pesticides.

TABLE 2.1-1

HEAVY METAL CONCENTRATIONS IN WATERS OF DETROIT RIVER, LAKE ST. CLAIR, ST. CLAIR RIVER

Date	Station(s)	Samples	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn	Information Source
		ppb (µg/L) [(a)]														
1972-77	Port Huron WTP St. Clair River	10	<1-1	<.1-.5	1-5		2-5 [(b)]	4-6	<.1-.5		<5-10	<2	<1-1 [(b)]		2-13 [(b)]	77
1973-77	Detroit Water Works Detroit River	10	<1-.2	<.1-1	2-4		2-16 [(b)]	<1-8	<.1-.5		<5-9	<2	<1-1 [(b)]		6-25 [(b)]	77
1973-77	Ecorse River	5	1-3 [(b)]	<1-1			6-14 [(b)]	<5-35	<.2-.1		10-22	<1	<1-3 [(b)]		23-28 [(b)]	77
1977	Detroit River Range 3.9 Near Rockwood															77
	2,500' from w. shore	2					5-6	10-14	<.1-.1							
	5,500' from w. shore	2					2-3	10-12	<.1-.1							
	7,500' from w. shore	2					4-5	10-13	<.1							
	9,500' from w. shore	2					2	10-12	<.1-.1							
	11,500' from w. shore	2					2	6-11	<.1							

(a) total metal unless otherwise specified

(b) dissolved fraction

TABLE 2.1-2

HEAVY METAL CONCENTRATIONS OBSERVED IN WATER AND SEDIMENTS OF DETROIT AND ST. CLAIR RIVERS DURING 1973-74 - EPA CONTRACT NO. 68-01-1570(76)

LOCATION	Range of Means of Heavy Metal Concentrations — Water (μg/L) / Sediment (mg/kg)						
	Cd	Cr	Cu	Pb	Hg	Ni	Zn
St. Clair River - Mouth Lake Huron (2 sites)		2.7-5.4	4.8-6.0	2.2-2.3	3.3-4.6	10-20	51-111
		20-30	11-16	6-29	.18	10-32	33-59
Detroit River - Peche Island Area (3 sites)	.29-.33	4.8-9.1	4.6-7.1	2.0-2.7	4.0-4.4	14-16	63-87
	1.4-2.6	30-87	9-14	15-30	.19-.50	24-32	44-81
Detroit River - below Mouth of Ecorse River (2 sites)	.25-.33	6.7-16.7	15-16.3	4.1-9.6	1.5-3.6	18-26	65-89
	1.8-8.5	32-962	16-116	27-289	.19-.61	19-142	77-335
Mouth of Detroit River Lake Erie (4 sites)	.31-.95	4.3-17.1	5.8-12.0	3.4-9.2	2.4-3.1	15-31	65-84
	2.7-7.6	98-353	16-83	35-123	.17-1.45	23-66	117-346

TABLE 2.1-3

ORGANIC COMPOUNDS IDENTIFIED IN THE WATERS OF LAKE ST. CLAIR, DETROIT RIVER AND ST. CLAIR RIVER

SAMPLING STATION AND DATE	ORGANIC COMPOUNDS AND CONCENTRATIONS	ppb	INFORMATION SOURCE
Maple Beach, Gibralter, MI, Detroit River 1976	C_7 Alcohol	1	18
	C_8 Alcohol	1	
	C_9 Alcohol	2	
	C_{10} Alcohol	2	
	C_{11} Alcohol	2	
	C_{12} Alcohol	3	
	C_{13} Alcohol	3	
	C_{14} Alcohol	3	
	C_{15} Alcohol	3	
	C_{16} Alcohol	3	
	C_{17} Alcohol	4	
	C_{18} Alcohol	6	
	C_{19} Alcohol	4	
	C_{20} Alcohol	7	
	C_{21} Alcohol	5	
	C_{22} Alcohol	6	
	C_{23} Alcohol	4	
	C_{24} Alcohol	3	
	C_{26} Alcohol	2	
	Camphor (IS)	-	
	Dibutyl Phthalate	1	
	Dichlorobutene	1	
	Diethyl Hexyl Phthalate + C_{25} Alcohol	3	
	Methyl-2-Ethyl Hexanoate (IS)	-	
	Methyl Myristate	1	
	Methyl Palmitate	12	
	Methyl Stearate	16	
	C_{15} Terpineol	1	
Detroit, 1/6 mile from shore, Detroit River	Diethyl Hexyl Phthalate	6	18
	Methyl-2-Ethyl Hexanoate (IS)	-	
	Methyl Palmitate	6	
	Methyl Stearate	8	
	1,1,2,2-Tetrachloroethane	1	
Port Huron, St. Clair River midstream	Camphor (IS)	-	18
	Chloroform	4	
	Dibutyl Phthalate	2	
	Methyl-2-Ethyl Hexanoate (IS)	-	
	Methyl Palmitate	2	
	Methyl Stearate	1	
Algonac, MI, St. Clair River midstream	Chloroform	1	18
Windsor, Ontario WTP Intake 1976	Chloroform	2	78
	Bromodichloromethane	0.2	
	Chlorodibromomethane	0.01	
	Bromoform	<.1	
Treated 1976	Chloroform	6-10	78
	Bromodichloromethane	1-6	
	Chlorodibromomethane	1-3	
	Bromodichloromethane	<.1-1	

TABLE 2.1-4

ORGANIC CONTAMINANT SURVEY - WATERS OF

DETROIT RIVER, LAKE ST. CLAIR, ST. CLAIR RIVER(a)

ORGANIC CONTAMINANTS SOUGHT AND DETECTION LEVELS (μg/L)

DBP:	1.0	Cyanide:	0.1-10	Aroclor 1242:	0.1
DEHP:	1.0	2,4-D:	0.05-5.0	Aroclor 1254:	0.1
Toxaphene:	1.0	Silvex:	1.0	Aroclor 1260:	0.1
Chlordane:	0.1	Endrin:	0.02	Dieldrin:	0.003
Lindane:	0.05	Heptachlor:	0.02	o,p-DDT:	0.01
Methoxychlor:	0.05-5	PCBs:	0.1-0.3	Phenol:	.1-2

LOCATION	ORGANIC CONTAMINANTS FOUND, CONCENTRATIONS (μg/L) AND DATE
Algonac WTP St. Clair River 1975-77	none
Port Huron WTP St. Clair River 1974-77	Cyanide - 0.1-0.5 P,P-DDT - 0.014 (07/74) DBP - 1.0 (07/74) DEHP - 1.6-4.6 (07/74, 10/75) Phenol - .4-2 (10/75 - 01/77)
*Detroit River - Range 30.8 1972-77 (Detroit to Peche Island)	Cyanide 0.1 (07/77)
Detroit WTP Detroit River 1972-77	DEHP - 5.7 (01/76) Phenol - <.5 - 5 (05/72 - 04/77) Cyanide - .2 (04/77)
*Detroit River - Ranges 14.6-20.6 (Detroit to Windsor) 1972-77	Cyanide - 0.2-13 (05/77 - 09/77)
*Ecorse River 1973-77	Cyanide - 5-10 (11/76 - 09/77)
*Detroit River - Ranges 3.9-12.0 1972-77	Cyanide - 0.4-20 (10/72 - 09/77)

(a) Storet retrieval - Michigan Department of Natural Resources

* Analyses only for cyanides and heavy metals.

2.2 DATA ON SEDIMENT QUALITY

Heavy Metals

As in the case of Lake Erie, the recognition of mercury discharges to the St. Clair River and the Detroit River, resulted in the initiation of several efforts to evaluate the extent of contamination by mercury. Many studies evaluated concentrations of several heavy metals in addition to mercury. The results of the efforts are shown in Tables 2.2-1, 2.2-2 and 2.2-3 (9, 22, 31, 76, 79-82). Figure 2.2-1 illustrates the sampling sites of separate studies on the St. Clair River and Lake St. Clair by the Ontario Ministry of the Environment, the U.S. Depart_ ment of Interior and the Michigan Department of Natural Resources. The Roman numerals in Figure 2.2-1 indicate four areas designated by the Michigan DNR and the heavy metal concentrations in the four areas are shown in Table 2.2-3. Figures 2.2-2 and 2.2-3 illustrate the extent of the U.S. Department of Interior studies on the Detroit River.

PLUARG (9) reported in 1978 that in Lake St. Clair the mean mercury values in sediments have decreased from 1.55 mg/kg in 1970 to 0.54 mg/kg in 1976. On the basis of Figure 2.2-4, PLUARG reported that "Lake St. Clair is still a major source of mercury to Lake Erie, even seven years after shutdown of the point source discharge. The sediments of Lake St. Clair, laden with mercury, are gradually being washed out through the Detroit River and deposited in the western basin of Lake Erie." With regard to other heavy metals, the studies of the Detroit River sediments in 1970 by the Department of Interior and in 1973-74 by the Environmental Control Technology Corporation (76), are of particular interest. Eight to twenty fold increases in concentrations of mercury, lead, zinc, nickel, chromium and copper were observed during 1970 in sediments at the mouth of the Detroit River (Lake Erie), when compared to the sediments at the head of the Detroit River (see Table 2.2-1). The 1973-74 study (76) also showed increases in the heavy metal concentrations, however, the magnitudes of the increases were somewhat less than observed in 1970 (Table 2.1-2). Figure 1.2-8 illustrates similar increases for lead within the Lake St. Clair - Detroit River - Lake Erie system.

Organic Contaminants

Table 2.2-4 summarizes some of the available data for organic contaminants in sediments of the Detroit River, Lake St. Clair and St. Clair River (42, 43, 80, 81). Comparisons of 1970 and 1974 levels of organochlorine insecticides and PCBs in Lake St. Clair are shown in Table 2.2-5 and Figures 2.2-5 and 2.2-6. PLUARG in its 1976 report to the Commission (42), stated that "a statistically significant decrease in mean concentration of DDT and metabolites of approximately 60% has occurred between the two surveys (1970, 1974). PCBs also show a decline of approximately 50% over the same time interval." The decrease was ascribed to two phenomena "firstly, decrease in source due to the 1970 ban on DDT and the voluntary restraint on PCBs use requested in 1971. Secondly, the shallow water nature of Lake St. Clair results in the resuspension of bottom sediment and movement to the Detroit River."

The analyses of suspended solids (Table 2.2-6) from the Detroit River showed that suspended solids derived predominantly from Lake St. Clair were supplemented by additional sources within the Detroit River with regard to DDT, HEOD (Dieldrin), heptachlor epoxide, chlordane and PCBs (43). Extensive discussions on the levels of insecticides and PCBs in Lake St. Clair are found in reference 43.

Recently published results in a PLUARG Task C report (170), indicate the levels of pesticides which were found in streambed sediments of Big Creek (AG-1) and Holiday Creek (AG-5). The results are shown in the chapter of Lake Erie under Table 1.2-14.

TABLE 2.2-1

METAL ANALYSES - SEDIMENTS FROM

ST. CLAIR RIVER, LAKE ST. CLAIR, DETROIT RIVER

SAMPLE DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	CONCENTRATION - ppm dry weight								INFORMATION SOURCE
			MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	
1970	St. Clair River (See Figure 2.2-1)	3 12	0.2-1.0 *								22
1970	Lake St. Clair (navigation channel)	6	0.3-9.2								22
	Lake St. Clair (disposal site of dredged material from St. Clair River)	2	1.7-2.1								
	Lake St. Clair	15	*								
1970	Head, Detroit River	1	<1.0	22	35	10		<30	9	9	22
1970	Upper Detroit River	5	0.7-1.4								
	(upstream from Rouge River) (See Figure 2.2-2)	9	*								
1970	Rouge River	6	*								
1970	Mouth of Rouge River (Detroit River)	1	<1.0	54	110	30		<30	26	41	22
1970	Detroit River (N. of Nicholson Dock)	1	6.0	110	430	80		<30	99	79	22
1970	Mouth of Ecorse Creek (Detroit River)	1	<1.0	900	1,300	230		<30	540	290	22
1970	Detroit River (Trenton Channel-20 ft. from shore - See Figure 2.2-3	21	<0.5-86								

*less than "measurable limit of 0.5 mg/kg wet weight"
(as reported in Ref. 22)

TABLE 2.2-1 (CONT'D)

SAMPLE DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	INFORMATION SOURCE
			CONCENTRATION - ppm dry weight								
1970	Detroit River (Trenton Channel-≤20 ft. from shore)	30	< 0.5-26								22
1970	Lower Detroit River (Excluding Trenton Channel)	5 23	0.6-4.4 *								22
1970	Detroit River, Mouth	1	2.6	160	600	100		<30	190	140	22
1970	Lake St. Clair		1.55								9
1972-76	St. Clair River (See Table 2.2-2 and Figure 2.2-1)	6									79
	-Sarnia (head of St. Clair River)		<0.01-0.18								
	-Sarnia		0.01-112								
	-Corunna		<0.01-12.2								
	-Courtright		0.01-7.6								
	-Sombra		0.13-3.4								
	-Port Lambton		0.02-2.7								
1972-76	Chenal Ecarte (See Table 2.2-2)	2	1.6-36.6								79
1972-76	Lake St. Clair (See Table 2.2-2 and Figure 2.2-1)	4	0.04-4.6								79

TABLE 2.2-1 (CONT'D)

SAMPLE DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	CONCENTRATION - ppm dry weight								INFORMATION SOURCE
			MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	
1973	Lake St. Clair (see Table 2.2-3 and Figure 2.2-1)	28	0.62±0.96 (0.002-3.33)	18.8±21.7 (<1-91)	70±53 (12-228)	19±16 (1.4-63.2)	1.1±0.5 (<1.0-2.1)	0.54±0.55 (<0.2-2.1)	12.1±9.3 (2.5-38.6)	16.4±13.5 (2.0-52.6)	80
1973	Blade River		0.15	26	64	12		1.6	16	48	31
1973	Talford Creek		2.77	17	49	14		1.8	11	16	31
1973	Pine River		0.19	22	49	10		1.2	11	13	31
1973	Belle River		0.07	16	31	9		0.9	8	5	31
1973	St. Clair River		0.63	12	32	11		1.6	6	8	31
1973	Rouge River		0.81	151	330	49		5.5	78	81	31
1973	Rouge River Canal		0.16	15	43	21		1.9	14	15	31
1973-74	St. Clair River and Detroit River (see Table 2.1-2)		✓	✓	✓	✓		✓	✓	✓	76
1974	Lake St. Clair (average)		.57								9
1975	Thames River	60		<3-27	13-90					<3-26	81
1975	Clinton River	5	<1.-.2	140-250	210-410	54-110	5-7	1.7-5.4	59-130	62-120	82
1976	Lake St. Clair (average) (also see Figure 2.2-4)		0.54								9

TABLE 2.2-2

SUMMARY OF MERCURY RESULTS - ONTARIO MINISTRY OF THE ENVIRONMENT
SEMI-ANNUAL ASSESSMENT PROGRAM(a)
ST. CLAIR SYSTEM, 1972-1976

Location	Distance from Can. Shore (ft.)	Total Mercury Concentration mg/kg							
		Dec/72	May/73	Nov/73	May/74	Dec/74	May/75	Nov/75	May/76
Bedload	25	.09	.08	.11	.07	.18	.07	.02	.03
Section	50	–	.06	.05	.16	.03	.06	.03	–
1	100	–	.07	.03	.06	.02	.12	.03	.07
	150	<.01	.04	.02	.04	.02	.025	.08	.04
Sarnia	200	.03	.04	.01	.02	.03	.015	.03	.04
	250	<.01	.01	.01	.03	.01	.02	–	<.01
	300	<.01	.01	–	<.01	.02	<.01	<.01	<.01
Bedload	25	12.2	30.6	8.4	.60	8.1	7.5	–	–
Section	50	6.9	6.9	25.7	.40	16.0	7.7	7.5	2.0
2	100	89.6	112.0	17.7	94.2	58.0	5.3	48.3	25.0
	150	8.3	12.6	4.1	18.0	5.7	3.3	6.76	3.6
Sarnia	200	6.8	–	14.0	8.0	18.0	3.7	3.23	4.3
	250	6.7	–	2.81	5.6	18.9	2.5	3.42	1.5
	300	3.0	–	2.3	2.9	1.1	1.4	4.80	2.1
	400	.03	–	.05	.03	.01	.022	.02	.01
Bedload	50	–	–	12.2	4.4	3.7	1.4	–	7.6
Section	100	3.0	11.2	6.1	1.6	4.2	2.0	1.59	1.2
3	200	4.6	4.0	2.6	11.4	3.8	2.7	3.87	3.3
	300	4.2	3.1	2.1	3.28	1.3	1.7	1.32	2.1
Corunna	400	.7	–	1.2	1.02	2.1	.67	.85	1.3
	500	<.01	.05	.05	.055	.03	.034	.04	–
	600	<.01	.02	.02	.86	.04	<.01	.01	.01

(Cont'd)

TABLE 2.2-2

SUMMARY OF MERCURY RESULTS (CONTINUED)

Location	Distance from Can. Shore (ft.)	Total Mercury Concentration mg/kg							
		Dec/72	May/73	Nov/73	May/74	Dec/74	May/75	Nov/75	May/76
Bedload	50	-	-	1.2	-	1.6	-	2.26	1.7
Section	100	5.5	5.9	7.6	1.56	2.7	1.1	2.49	2.9
4	200	6.2	3.1	4.4	3.34	2.7	3.3	2.32	2.4
	300	4.8	4.3	5.0	4.14	3.7	1.7	2.71	4.1
Court-	400	2.5	6.1	2.4	2.31	2.1	2.9	1.31	1.1
right	500	.18	2.6	1.6	2.40	1.4	.95	1.63	1.4
	600	.01	.92	0.4	.23	.20	1.7	.74	.69
Bedload	100	-	-	2.5	2.68	1.4	-	1.49	1.8
Section	200	3.4	2.4	2.2	2.31	1.3	2.2	1.41	1.4
5	300	1.4	1.55	1.4	2.14	1.3	1.2	1.48	2.7
	400	1.2	1.86	1.1	1.21	2.3	.81	.83	0.56
Sombra	500	1.6	.88	2.7	.58	2.0	.94	.50	1.60
	600	1.3	1.52	.27	1.09	.32	.39	.24	.75
	700	.73	.51	.18	.61	.21	.25	.13	.30
Bedload	100	-	-	-	1.84	2.0	2.3	2.07	1.5
Section	200	2.1	2.72	2.4	1.72	1.0	.50	.86	1.3
6	300	1.9	1.18	1.3	1.06	2.3	.83	.61	.61
	400	.48	.65	.97	.65	.57	.53	.43	.51
Point	500	1.48	.40	.44	.34	.31	.52	.26	.34
Lambton	600	.15	.24	.15	.14	.51	.20	.13	.13
	700	.18	.09	.02	.16	.11	.092	.08	.12

(Cont'd)

SUMMARY OF MERCURY RESULTS (CONTINUED)

Location	Total Mercury Concentration mg/kg						
	Jun/73	Nov/73	May/74	Dec/74	May/75	Nov/75	May/76
Station 200(69) Chenal Ecarte	23.9	1.8	1.39	1.6	2.0	1.7	1.9
Station 205(74) Chenal Ecarte	36.6	1.6	2.51	3.3	1.5	1.01	1.7
Station 91 Lake St. Clair	0.32	0.23	1.21	0.18	0.16	0.13	0.18
Station 402 Lake St. Clair	0.12	0.04	0.07	-	0.82	0.05	0.04
Station 110 Lake St. Clair	2.46	2.5	3.45	2.0	2.0	1.49	2.2
Station 163 Lake St. Clair	2.98	-	1.73	1.2	4.6	0.48	0.72

(a) See Figure 2.2-1 for approximate sampling site locations.

Table 2.2-3 Mean heavy metal concentrations in the surface sediments of Lake St. Clair, August 13-16, 1973. All concentrations, except for oils (percent), presented on dry weight basis in mg/kg ± one standard deviation.

Area(a)	Cd	Pb	Ni	Zn
I	0.34 ± 0.25	20.59 ± 13.95	16.1 ± 7.7	58.0 ± 26.2
II	1.02 ± 0.62	15.43 ± 1.32	14.9 ± 4.7	80.8 ± 52.8
III	0.39 ± 0.26	4.97 ± 6.56	5.8 ± 4.2	32.4 ± 23.7
IV	0.97 ± 0.90	32.42 ± 38.19	42.5 ± 14.4	132.7 ± 65.8
Range	<0.2 - 2.1	<1.0 - 91.2	1.4 - 63.2	12.2 -228.1
Lake $\overline{X}$	0.54 ± 0.55	18.79 ± 21.67	19.2 ± 15.8	69.6 ± 52.8

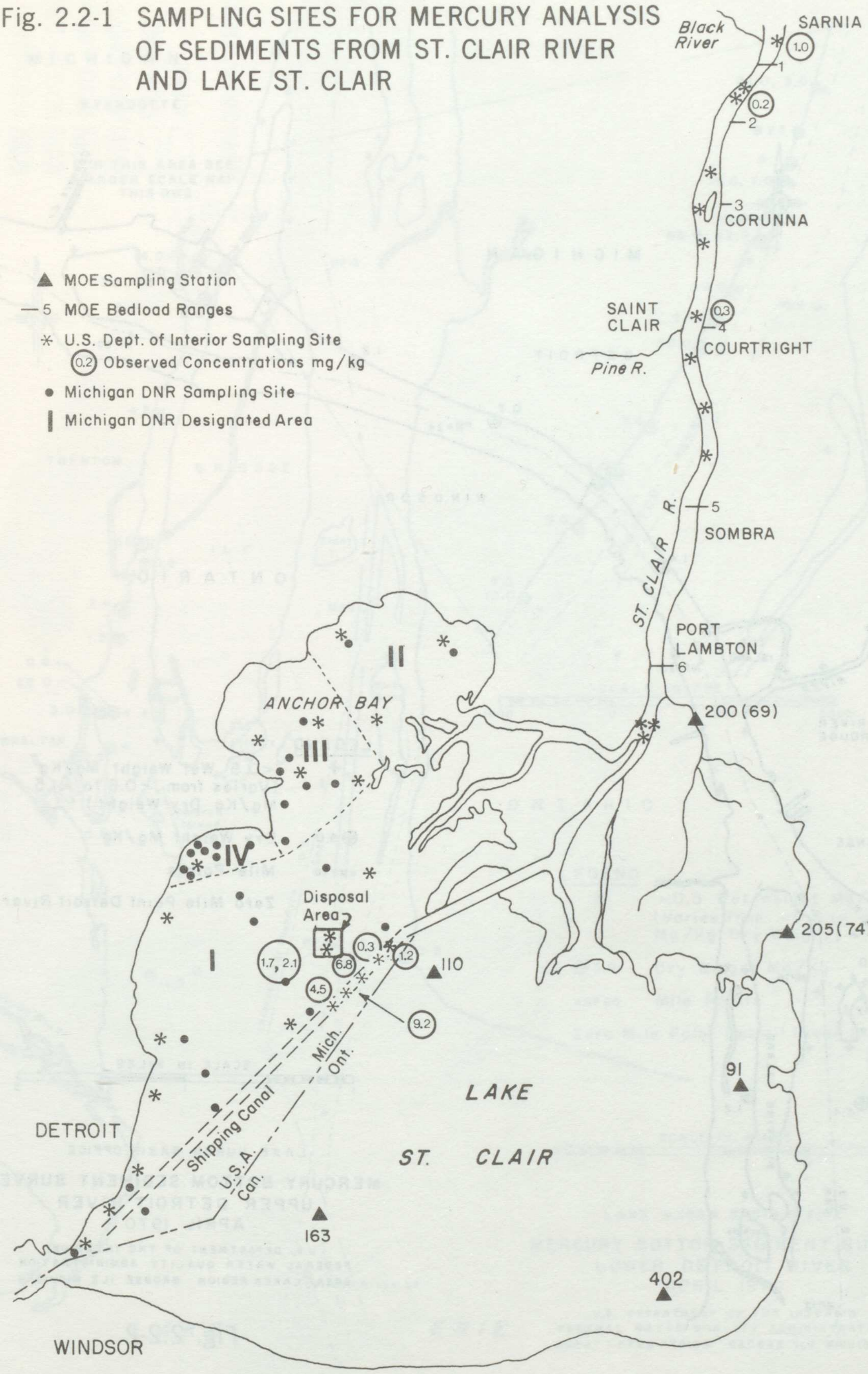
	Cu	Cr	As	Se
I	18.26 ± 10.98	10.46 ± 4.58	1.3 ± 0.5	<1.0 ± 0.0
II	16.89 ± 9.54	8.50 ± 1.36	1.3 ± 0.8	<1.0 ± 0.0
III	10.58 ± 14.60	4.63 ± 1.85	0.8 ± 0.4	<1.0 ± 0.0
IV	25.53 ± 18.47	25.46 ± 9.54	1.0 ± 0.4	<1.0 ± 0.0
Range	2.0 - 52.6	2.5 - 38.6	<1.0 - 2.1	<1.0
Lake $\overline{X}$	16.41 ± 13.46	12.14 ± 9.26	1.1 ± 0.5	<1.0

	Hg	TKN	Oils (%)
I	1.087 ± 1.294	854.9 ± 433.6	0.41 ± 1.14
II	0.359 ± 0.263	806.2 ± 299.8	0.11 ± 0.09
III	0.165 ± 0.170	280.9 ± 195.6	0.02 ± 0.01
IV	0.317 ± 0.251	1056.6 ± 303.7	0.11 ± 0.07
Range	0.02 - 3.33	129.9 - 1539	-
Lake $\overline{X}$	0.623 ± 0.955	747.3 ± 442.5	0.22 ± 0.75

(a) See Figure 2.2-1 for allocation of areas.

Data supplied by Michigan Department of Natural Resources

Fig. 2.2-1 SAMPLING SITES FOR MERCURY ANALYSIS OF SEDIMENTS FROM ST. CLAIR RIVER AND LAKE ST. CLAIR



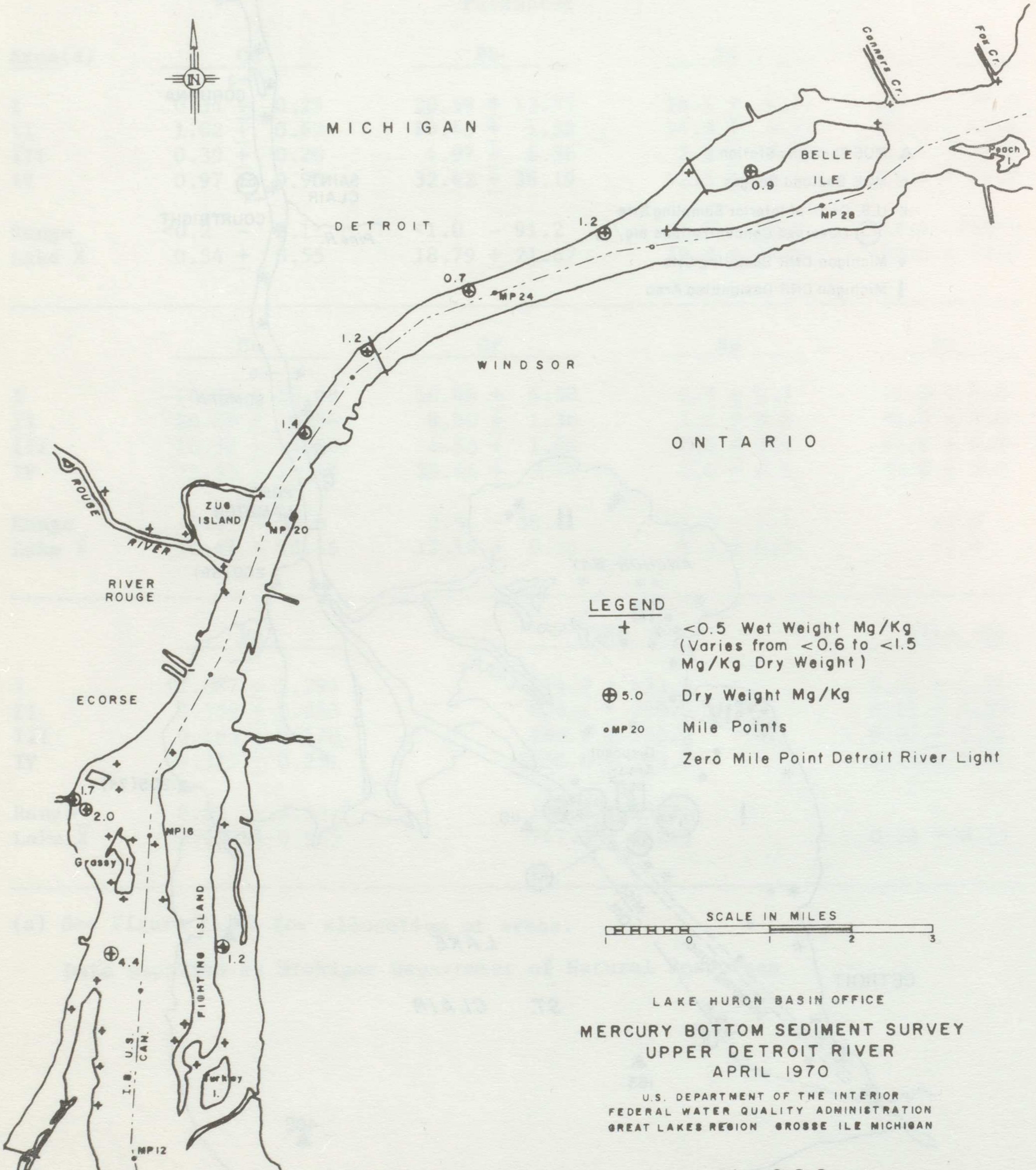
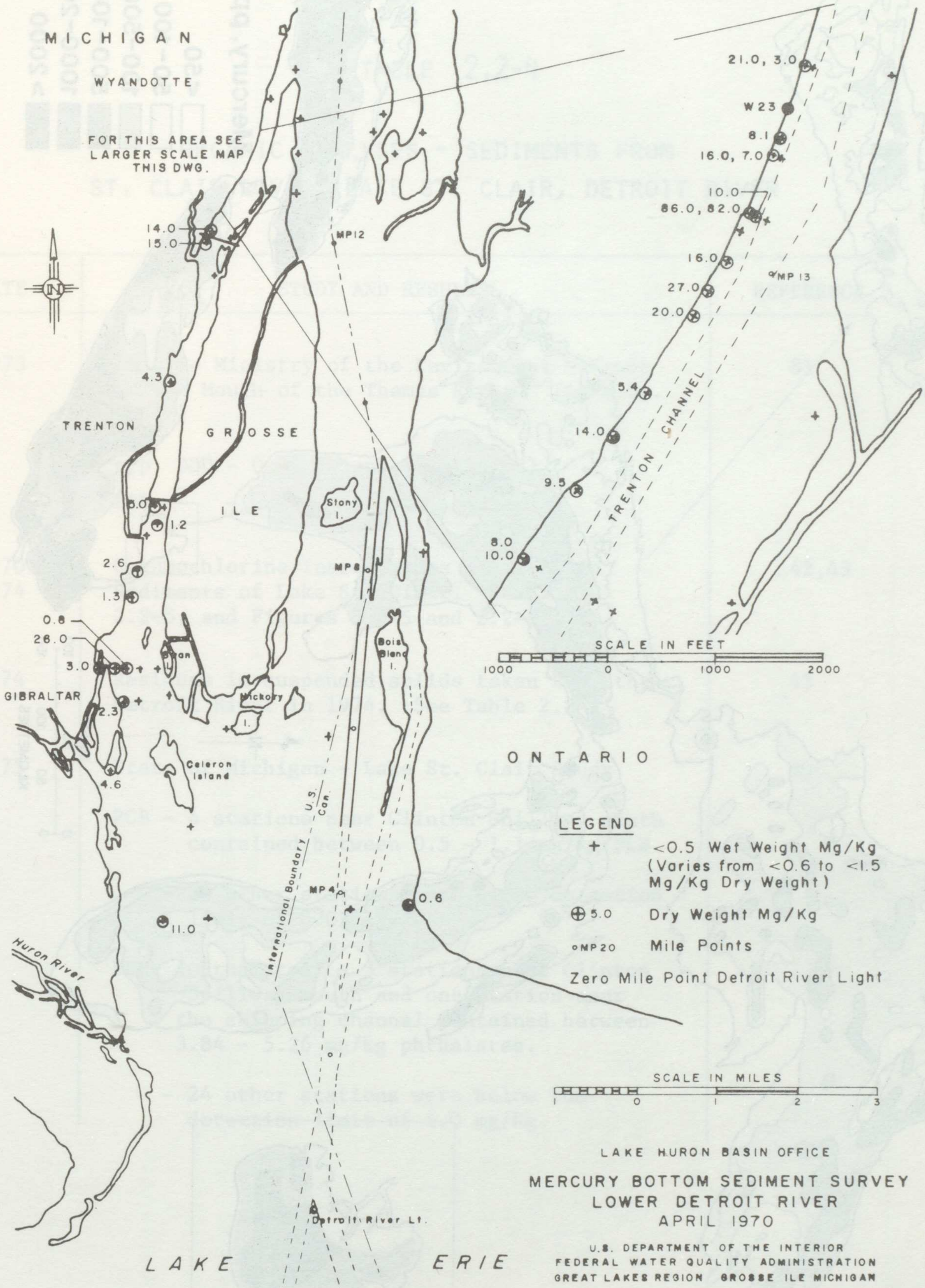

MICHIGAN
DETROIT
WINDSOR
ONTARIO
BELLE ILE
Peach I.
Conners Cr.
Fox Cr.
ZUG ISLAND
ROUGE RIVER
RIVER ROUGE
ECORSE
Grassy I.
FIGHTING ISLAND
Turkey I.
I.B. U.S. CAN.
MP 28
MP 24
MP 20
MP 16
MP 12
0.9
1.2
0.7
1.2
1.4
1.7
2.0
4.4
1.2
N
LEGEND
+ <0.5 Wet Weight Mg/Kg (Varies from <0.6 to <1.5 Mg/Kg Dry Weight)
⊕5.0 Dry Weight Mg/Kg
•MP20 Mile Points
Zero Mile Point Detroit River Light
SCALE IN MILES
1 0 1 2 3
LAKE HURON BASIN OFFICE
MERCURY BOTTOM SEDIMENT SURVEY
UPPER DETROIT RIVER
APRIL 1970
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER QUALITY ADMINISTRATION
GREAT LAKES REGION GROSSE ILE MICHIGAN

Fig. 2.2-2



MICHIGAN
WYANDOTTE
FOR THIS AREA SEE LARGER SCALE MAP THIS DWG.
TRENTON
GROSSE
ILE
GIBRALTAR
Stony I.
Bois Blanc I.
Hickory I.
Celeron Island
Huron River
International Boundary
U.S. Can.
MP12
MP8
MP4
MP 13
TRENTON CHANNEL
ONTARIO
Detroit River Lt.
LAKE
ERIE
21.0, 3.0
W23
8.1
16.0, 7.0
10.0
86.0, 82.0
16.0
27.0
20.0
5.4
14.0
9.5
8.0
10.0
14.0
15.0
4.3
5.0
1.2
2.6
1.3
0.8
26.0
3.0
2.3
4.6
11.0
0.6
SCALE IN FEET
1000 0 1000 2000
LEGEND
+ <0.5 Wet Weight Mg/Kg (Varies from <0.6 to <1.5 Mg/Kg Dry Weight)
5.0 Dry Weight Mg/Kg
MP20 Mile Points
Zero Mile Point Detroit River Light
SCALE IN MILES
1 0 1 2 3
LAKE HURON BASIN OFFICE
MERCURY BOTTOM SEDIMENT SURVEY
LOWER DETROIT RIVER
APRIL 1970
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER QUALITY ADMINISTRATION
GREAT LAKES REGION GROSSE ILE MICHIGAN

Fig. 2.2-3

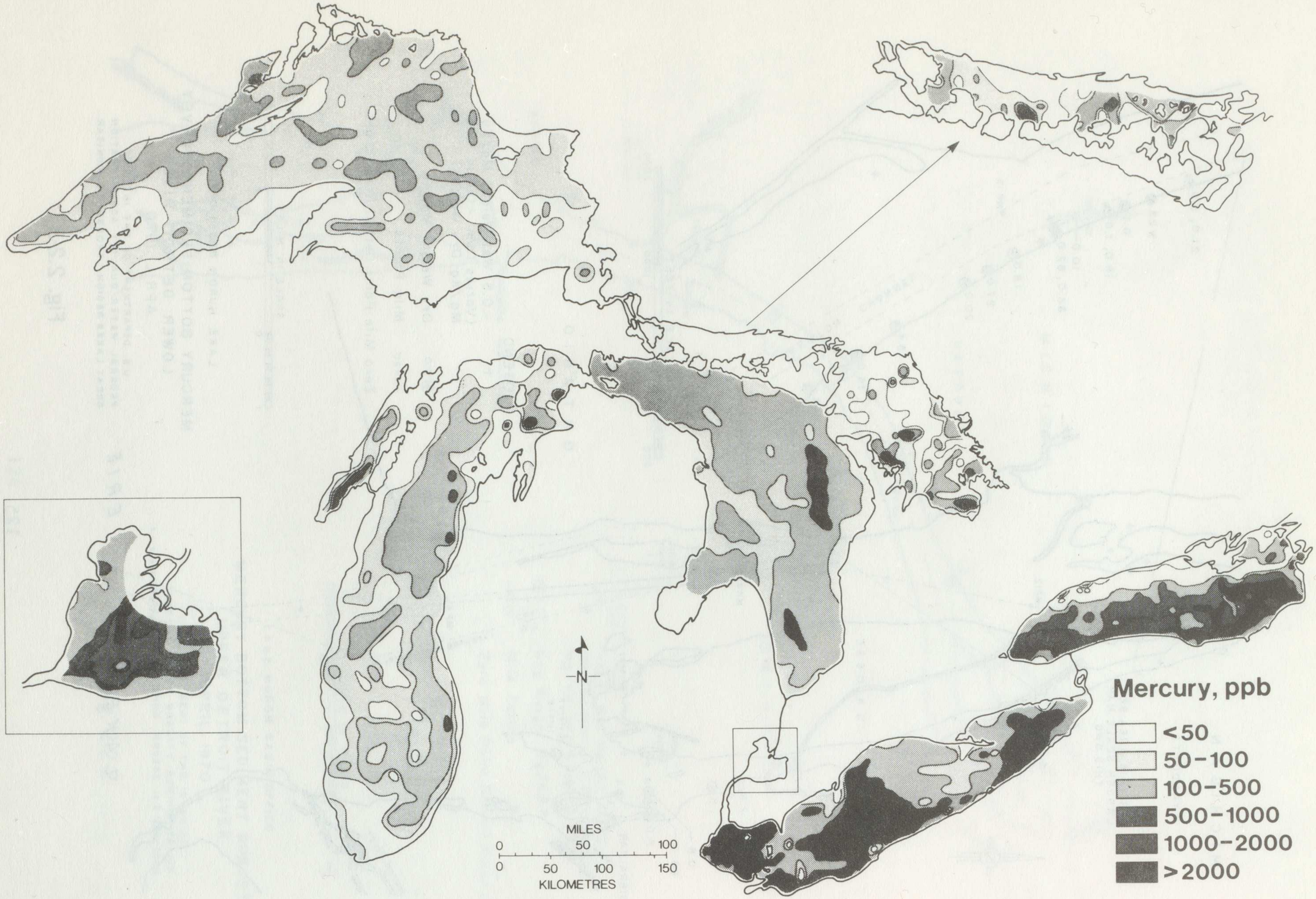


FIGURE 2.2-4. MERCURY CONCENTRATIONS IN SURFACE SEDIMENTS OF THE GREAT LAKES (PPB - μG/KG).

TABLE 2.2-4

ORGANIC ANALYSES - SEDIMENTS FROM ST. CLAIR RIVER, LAKE ST. CLAIR, DETROIT RIVER

DATE	STUDY AND RESULTS	REFERENCE
1973	Ontario Ministry of the Environment - Study at the Mouth of the Thames River. (Lake St. Clair) p,p DDD - 0 - 5 ppb (6 samples) PCB - 0 - 50 ppb (6 samples)	81
1970 - 1974	Organochlorine Insecticides and PCBs in Sediments of Lake St. Clair. See Table 2.2-5, and Figures 2.2-5 and 2.2-6.	42,43
1974	Residues in suspended solids taken from the Detroit River in 1974. See Table 2.2-6	43
1975	State of Michigan - Lake St. Clair Study PCB - 4 stations near Clinton Spillway mouth contained between 0.5 - 1.1 mg/kg PCB - 24 other stations were below detention limit of 0.05 mg/kg DEHP (phthalates) - 3 stations near Clinton Spillway mouth and one station near the shipping channel contained between 3.84 - 5.26 mg/kg phthalates. - 24 other stations were below the detection limit of 1.0 mg/kg.	80

Table 2.2-5 Comparative mean values for organochlorine insecticides and PCB in Lake St. Clair Sediments (1970 and 1974) (Ref. 42 and 43)

Year		p,p'DDE	p,p'TDE	o,p'DDT	p,p'DDT	ΣDDT	HEOD	Endosulfan	PCB
1970	mean (ppb)	2.0	3.6	<0.1	0.9	6.6	0.1	0.2	19
(50 *	SD (ppb)	1.5	2.2	-	1.9	-	-	-	9
samples)	Min (ppb)	0.2	0.4	ND	ND	0.6	ND	ND	7
	Max (ppb)	8.2	8.5	1.5	6.6	22.7	0.9	2.2	40
	Presence (%)	100	100	6	46	100	24	20	100
	Limits of Detection	0.2	0.5	0.5	0.5	-	0.2	0.2	5
1974	mean (ppb)	0.7	1.5	ND	0.2	2.4	ND	ND	10
(54 *	SD (ppb)	0.6	1.6	-	0.4	-	-	-	6
samples)	Min (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
	Max (ppb)	2.7	7.3	-	1.6	11.2	ND	ND	28
	Presence (%)	96	96	0	33	96	0	0	98
	Limits of Detection	0.1	0.2	0.2	0.2	-	0.1	0.1	1
Significant at 0.01 level (t test)		6.1*	5.5*	-	3.7*	-	-	-	6.0

No heptachlor or heptachlor epoxide (<0.2 1970 and <0.1 ppb 1974), chlordane (2 ppb 1970 and 1 ppb 1974), endrin (<0.8 1970 and <0.4 ppb 1974), methoxychlor (<2.0 1970 and <1.0 ppb 1974), were detected to the limits of detection.

Twenty major organophosphorus insecticides were not detected to a limit of 5 ppb diazinon, 10 ppb parathion, 15 ppb ethion and 500 ppb azinphosmethyl or similar level for the respective compound based on comparative sensitivity to GLC - flame photometric detection.

* 4 km sample grid

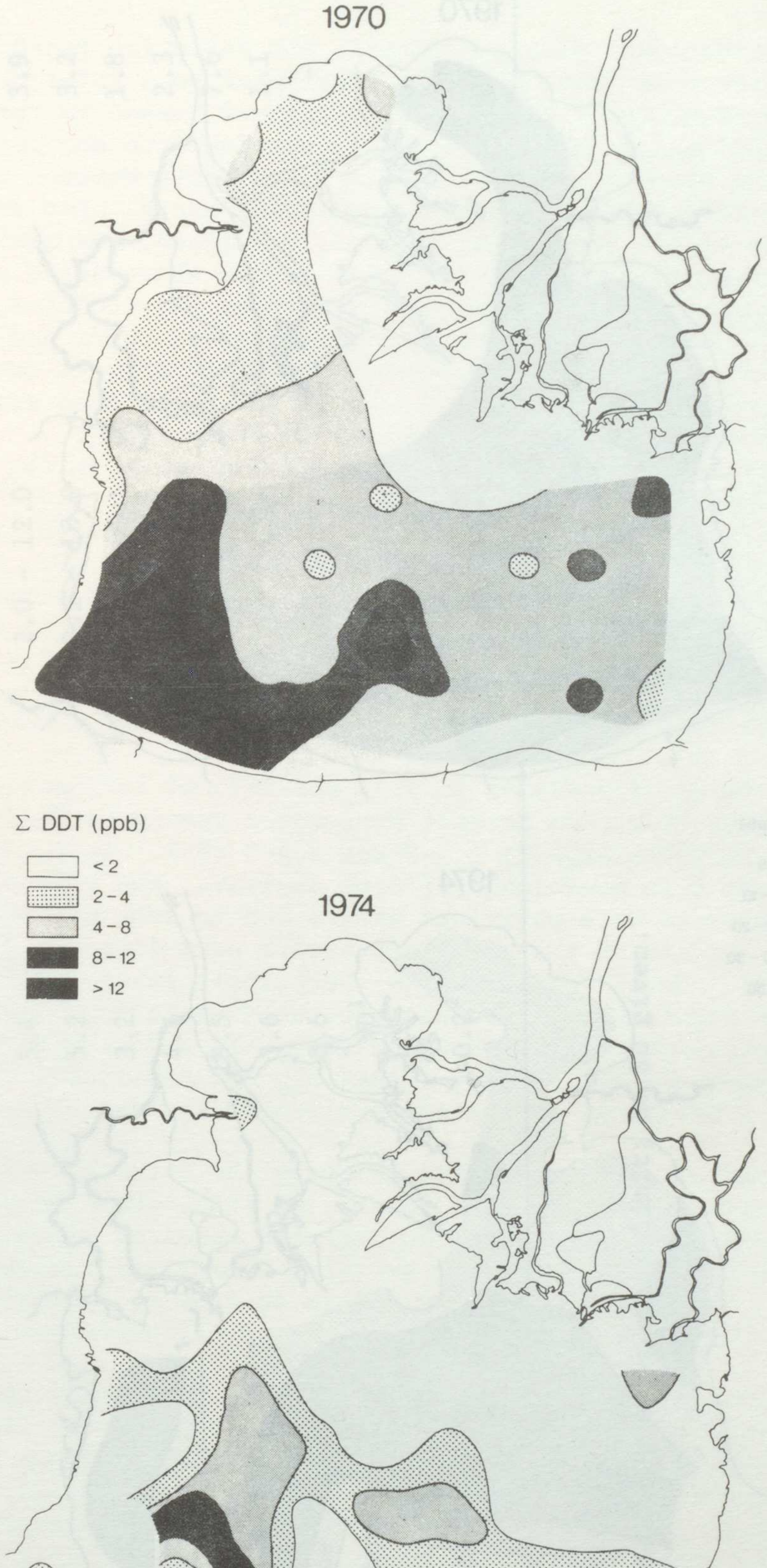


Fig. 2.2-5 Distribution of ΣDDT in freeze-dried sediments from Lake St. Clair; 1970 and 1974 (0–2 cm).

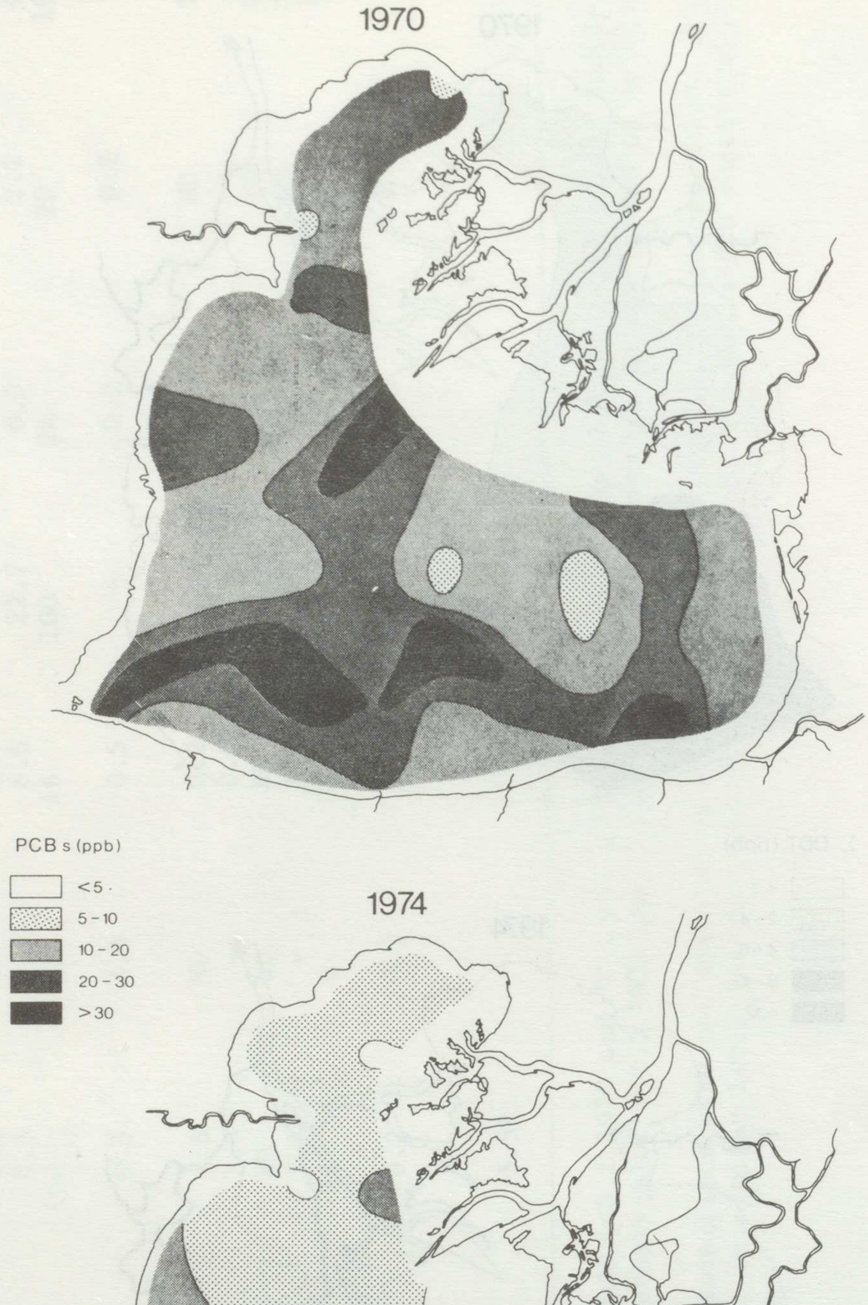


Fig. 2.2-6 Distribution of PCBs in freeze-dried sediments from Lake St. Clair; 1970 and 1974 (0–2 cm).

Table 2.2-6 Residues in suspended solids taken from the Detroit River in 1974 (Ref. 43)

	Constant ppb Dry Weight Basis		
Contaminant	Mean	Range	Std. Dev.
o,p'DDE	<0.1[2]	<0.1 - 0.2	-
p,p'DDE	5.4	2.0 - 12.0	3.9
p,p'TDE	5.2	3.1 - 10.0	3.2
o,p'DDT	3.2	0.9 - 6.1	1.8
p,p'DDT	4.6	2.1 - 7.1	2.3
ΣDDT	18.5	10.0 - 27.0	7.6
HEOD	3.6	1.9 - 5.1	1.1
Hept. Epoxide	0.6	ND - 2.0	-
Organophosphorus	ND[1]	ND	-
PCB	72	30 - 100	28
α & γ Chlordane	<0.2[2]	<0.2	-

[1]ND - not detected

[2]Mean of parameter at detection limit; no SD given.

2.3 DATA ON AIR QUALITY AND PRECIPITATION

An International Michigan-Ontario Air Pollution Board was established on February 3, 1976 pursuant to a reference from the governments of the United States and Canada to the International Joint Commission to examine into and report upon the state of air quality in the Detroit-Windsor and Sarnia-Port Huron areas on a continuing basis. Two annual reports of the Board (83, 84) were published, describing the air quality status and trends in the above noted areas. Substances monitored include: suspended particulates, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and "hydrocarbons." Details of the monitoring efforts are not included within this report because the substances are currently not of direct relevance to this report. Some detailed studies of air and precipitation in the Lake St. Clair Basin were recently completed. Table 2.3-1 outlines the levels of PAHs which were detected in air in the vicinity of Sarnia, Ontario (167). PLUARG studies (170, 172) have provided information on pesticide, metal and PCB levels in rainwater. The results are shown in tables 1.3-3 to 1.3-5, where AG-1 and AG-5 denote Lake St. Clair watersheds.

2.4 DATA ON MUNICIPAL AND INDUSTRIAL DISCHARGES AND SLUDGES

The results of analyses in 1973 and 1975 of influents to, and effluents from, the Detroit Wastewater Treatment Plant are shown in Tables 2.4-1, 2.4-2 and 2.4-3 (85). As observed in the Lake Erie municipal effluent analyses, the predominant contaminants were phthalate esters and to some extent, Arochlor 1254. Levels of the phthalate esters were lower in 1975, than in 1973. Metal loadings from the Detroit plant in 1975 are highly significant. For example, an average chromium concentration of 160 ppb would result in a discharge of approximately 580 kgs/day chromium: 300 ppb nickel would imply a discharge of approximately 1080 kgs/day nickel.

Analyses of sludges and fly ash from the Detroit WWTP are summarized in Tables 2.4-1 and 2.4-4 (85). Mean levels of organochlorine pesticides in digested chemical sludges from Point Edward and Sarnia, Ontario are also summarized in Table 2.4-4 (86). The Ontario data was retrieved from an extensive report by Jones and Lee on municipal wastewater effluents and sludges (87).

Extensive analyses were made of various industrial discharges to the St. Clair River, by the Ontario Ministry of the Environment (88), and the results are shown in Table 2.4-5. It is understood analyses of sediments in the vicinity of the discharge areas are underway, however, the investigation has not been completed at the time of preparing this report.

Table 2.4-6 shows the results of a study to evaluate the release of PCBs and polychlorinated triphenyls on the vicinity of an investment casting facility in suburban Detroit (89).

TABLE 2.3-1

COMPARATIVE SEASONAL CONCENTRATION LEVELS OF PAH'S IN AIR OF ONTARIO CITIES
APRIL 1975-MARCH 1976

LOCATION: SOUTHERN SARNIA; SITE NO. 14061

	April-June 1975		July-Sept. 1975		Oct.-Dec. 1975		Jan.-March 1976	
	ng/1000 m^3 Air	µg/g p.m.*	ng/1000 m^3 Air	µg/g p.m.*	ng/1000 m^3 Air	µg/g p.m.*	ng/1000 m^3 Air	µg/g p.m.*
Benzo(a)pyrene	338	5.5	114	2.4	596	11.4	190	7.0
Benzo(e)pyrene	118	1.9	52	1.1	603	11.5	64	2.4
Benzo(b)fluoranthene	371	6.0	243	5.2	938	17.9	289	10.6
Benzo(k)fluoranthene	81	1.3	70	1.5	439	8.4	104	3.8
Perylene	27	0.4	13	0.3	87	1.7	19	0.7
Dibenz(def,mno)chrysene	23	0.4	8	0.2	44	0.8	7	0.3
Benzo(ghi)perylene	1038	16.8	1049	22.5	2700	51.7	1158	42.6
Naptho(1,2,3,4,def)chrysene	823	13.3	61	1.3	434	8.3	129	4.7
Benzo(rst)pentaphene	422	6.8	15	0.3	69	1.3	23	0.8
Dibenzo(b,def)chrysene	508	8.2	81	1.7	213	4.1	107	3.9

*Particulate matter

TABLE 2.4-1

SAMPLE ANALYSIS RESULTS (Ref. 85)

DETROIT

WASTEWATER TREATMENT PLANT

OCTOBER, 1973

PARAMETER	RAW WASTE (µg/L)	(lbs/day)	EFFLUENT (µg/L)	(lbs/day)	SLUDGE (mg/kg) DRY	% REMOVAL
Arochlor 1221	<.001	<.005	<.001	<.005	<.001 <.001 <.001	
Arochlor 1232	<.001	<.005	<.001	<.005	<.001 <.001 <.001	
Arochlor 1242	<.001	<.005	<.001	<.005	4.2 5.3 8.0	
Arochlor 1248	<.001	<.005	<.001	<.005	<.001 <.001 <.001	
Arochlor 1254	2.2	10.8	0.006	.03	3.2 2.0 4.5	99.7
Arochlor 1260	<.001	<.005	<.001	<.005	<.001 <.001 <.001	
Arochlor 1262	<.001	<.005	<.001	<.005	<.001 <.001 <.001	
Arochlor 1268	<.001	<.005	<.001	<.005	<.001 <.001 <.001	
Lindane	0.030	.15	0.003	.015	0.002 0.003 0.010	90
Heptachlor	0.035	.17	<.001	<.005	<.001 0.013 <.001	>97
Aldrin	0.160	.78	0.020	.10	<.001 0.026 0.051	88
Heptachlor epoxide	<.001	<.005	0.006	.03	<.001 0.013 0.030	
Dieldrin	0.153	.75	0.052	.25	0.004 0.013 0.005	66
Endrin	0.057	.28	0.054	.26	0.004 0.007 0.003	5.3
o,p-DDT	<.001	<.005	<.001	<.005	<.001 <.001 0.006	
p,p-DDT	<.001	<.005	<.001	<.005	<.001 0.010 0.026	

TABLE 2.4-1 (CONT'D)

SAMPLE ANALYSIS RESULTS

DETROIT

WASTEWATER TREATMENT PLANT

OCTOBER, 1973

PARAMETER	RAW WASTE (μg/L)	RAW WASTE (lbs/day)	EFFLUENT (μg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY	% REMOVAL
o,p-DDD	<.001	<.005	.005	.024	<.001 .001 <.001	
p,p-DDD	<.001	<.005	<.001	<.005	.008 .016 .041	
o,p-DDE	<.001	<.005	.004	.020	.002 .001 .006	
p,p-DDE	.15	.73	.030	.15	.008 .027 .039	80
Methoxychlor	.16	.78	.040	.20	<.001 <.001 <.001	75
Di-N-Butyl phthalate	430	2100	350	1700	17 35 25	19
Di-2-ethyl phthalate	560	2700	330	1600	37 44 49	41
Chlordane	<.001	<.005	.060	.25	.010 <.001 <.001	

TABLE 2.4-2

ORGANIC CONTAMINANT CONCENTRATIONS (μg/L)
DETROIT WASTEWATER TREATMENT PLANT - 1975

Ref. 85

PARAMETER	May 28 Inf.#1	May 28 Inf.#2	May 28 Effluent	May 29 Inf.#1	May 29 Inf.#2	May 29 Effluent	May 30 Inf.#1	May 30 Inf.#2	May 30 Effluent
Aroclor 1221	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aroclor 1242	2.5	<0.05	1.0	<0.05	<0.05	2.5	<0.05	<0.05	<0.05
Aroclor 1248	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aroclor 1254	<0.05	0.48	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aroclor 1260	0.87	<0.05	0.46	4.8	3.2	0.84	<0.05	4.5	0.77
Treflan (Trifluralin)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Hexachlorobenzene	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
B-BHC	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zytron (CAS 299-854)	0.061	<0.003	<0.005	<0.003	<0.003	<0.003	0.097	<0.005	<0.003
Isodrin	<0.003	<0.003	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Mirex	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
o,p-DDE	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
p,p-DDE	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
o,P-DDD	<0.003	<0.003	<0.003	<0.003	0.010	<0.003	<0.003	<0.003	<0.003
o,p-DDT	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
p,p-DDD	<0.003	<0.003	<0.003	0.026	0.140	0.042	0.036	0.25	0.054
p,p-DDT	<0.003	<0.003	<0.003	0.44	<0.003	<0.003	<0.003	<0.003	<0.003
Methoxychlor	0.93	0.69	0.25	<0.01	<0.01	1.6	0.57	9.4	0.88
Di-N-butyl Phthalate	7.6	8.5	1.4	8.2	3.6	48	25	3.5	5.7
Dieldrin	<0.003	<0.003	<0.003	0.027	<0.003	<0.003	<0.003	<0.003	<0.003
Endrin	0.32	0.18	0.11	0.14	0.34	0.16	0.13	0.39	0.24
Lindane	0.019	0.015	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	0.054
Aldrin	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chlordane	0.038	<0.002	<0.002	<0.002	0.075	<0.002	<0.002	0.044	<0.002
Diethylhexylphthalate	23	35	30	11	32	13	10	26	25
Heptachlor epoxide	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

TABLE 2.4-3

EFFLUENT ANALYSES - DETROIT WASTEWATER TREATMENT PLANT (Ref. 85)

Date	Location	Average Flow (MGD)	Concentration (µg/L) - effluent								
			Cd	Cr	Cu	Pb	As	Ni	Se	Zn	Hg
5/29/75	Detroit	950	16	160	150	110	7	300	<5	470	0.2
5/30/75	Detroit	950	35	160	120	120	7	330	<5	450	0.2
11/18/75	Detroit	950	16	146	97	76	3	290	<5	316	1.0
11/19/75	Detroit	950	18	230	131	100	4	340	<5	445	0.7

TABLE 2.4-5

ORGANIC COMPOUNDS IDENTIFIED IN INDUSTRIAL EFFLUENTS
ENTERING THE ST. CLAIR RIVER - SARNIA, ONTARIO 1975

ONTARIO MINISTRY OF THE ENVIRONMENT

Group A) Organohalides.

Compound.	No. of Sites Found.
Ethyl chloride	2
Vinyl chloride	11
Vinyl bromide	1
Chloro-propene	1
Dichloromethane	1
Dichloroethane	5
Dichloroethylene	2
Dichloropropane	6
Dichloropropene	1
Bromochloroethane	2
Dichlorobutadiene	1
Dibromomethane	2
Chloroform (trichloromethane)	10
Trichloroethylene	7
Trichloropropane	1
Tribromomethane (bromoform)	1
Carbon tetrachloride	1
Tetrachloroethane	5
Tetrachloroethylene	2
Hexachloroethane	1
Bis-2-chloroethyl ether	1

Group B) Aromatic Hydrocarbons.

Compound.	No. of Sites Found.
Benzene	3
Toluene	7
Xylenes	8
Propylbenzene	1
Diethyl benzene	1
Propyl toluene	1
Cumene	1
Styrene	1
Naphthalene	3
Methylnaphthalene	3
6-Methyl-1,2-dihydronaphthalene	1
Benzocyclobutene or phenylacetylene	1

Group C) Ethers, Alcohols, Carbony Compounds.

Compound.	No. of Sites Found.
Diethyl ether	16
Formaldehyde	1
Propanol	1
tert. Butanol	1
Decanols, etc.	2
Octadecanol	1
But-2-en-1-ol	1
Acetone	2
Methyl ethyl ketone	1

Group D) Aliphatic Hydrocarbons, Alkenes, Acetylenes.

Compound.	No. of Sites Found.
Cyclohexane	2
Butadiene	1
Buten-3-yne	1
Long chain alkanes	4

Group E) Other.

Compound.	No. of Sites Found.
N-(3,4-dichlorophenyl)-N', N'-diethylurea	1
Carbon disulphide	1

TABLE 2.4-6

RESULTS OF ANALYSIS OF VARIOUS SAMPLES TAKEN IN VICINITY OF INVESTMENT CASTING FACILITY IN SUBURBAN DETROIT, MICHIGAN

(Ref. 89)

Sample	Aroclor 1242	Aroclor 1260	Decachlorobiphenyl	Aroclor 5460
Cooling water discharge	<0.1 μg/L.	<0.1 μg/L.	<0.01 μg/L.	<0.1 μg/L.
Drainage water	<0.1 μg/L.	<0.1 μg/L.	<0.01 μg/L.	<0.1 μg/L.
Drainage water	<0.1 μg/L.	<0.1 μg/L.	<0.01 μg/L.	<0.1 μg/L.
Ditch sediment	2.3 ppm	6.7 ppm	0.09 ppm	6.7 ppm
Ditch sediment	9.4 ppm	8.9 ppm	0.11 ppm	5.1 ppm
Sanitary sewer water 1530, 2/22/75	<0.1 μg/L.	<0.1 μg/L.	<0.01 μg/L.	<0.1 μg/L.
Sanitary sewer water 1851, 2/22/75	<0.1 μg/L.	<0.1 μg/L.	<0.01 μg/L.	<0.1 μg/L.
Sanitary sewer water 1145, 2/23/75	<0.1 μg/L.	7.0 μg/L.	4.1 μg/L.	7.5 μg/L.
Sanitary sewer sludge deposits	<0.01 ppm	0.11 ppm	0.034 ppm	5.0 ppm

2.5 DATA ON BENTHOS AND PLANKTON

During preparation of this report, no data was found on contaminant levels in benthos and plankton from the Detroit and St. Clair Rivers and Lake St. Clair.

2.6 DATA ON FISH CONTAMINANTS

Trends of mercury concentrations in Lake St. Clair fish, have been evaluated by the U.S. Fish and Wildlife Service (90) (Table 2.6-1) and the Ontario Ministry of the Environment (91) (Table 2.6-2). Mean concentrations of mercury in fishes from Lake St. Clair decreased rapidly within 3-4 years of the reduction of mercury discharges. However, insignificant changes in the fish tissue levels have occurred from 1975 to 1977. Detailed analyses for the year 1976 are outlined in Table 2.6-3.

Tables 2.6-4 to 2.6-7 illustrate the concentrations of pesticides and PCBs which have been found in Lake St. Clair fish. (73, 92, 93)

In May 1978, Hallett et al. (94) reported the identification and quantification of several PAHs in carp and pike taken from the confluence of the Rouge and Detroit Rivers at Detroit, Michigan. Twenty-four compounds, which are listed in Table 2.6-8, were identified in Detroit River pike. Quantitation data for four compounds is shown in Table 2.6-9.

Recently Veith and Kuehl (95) have identified the presence of hexachlorobenzene, octachlorostyrene, cis-chlordane, trans-nonachlor and high concentrations of pentachloroanisole in fish from the Detroit River.

A PLUARG Task Group D report (171) gives the concentrations of various organochlorine and heavy metal residues in shiners from the Thames River. The results are shown in Tables 1.6-11 to 1.6-14 within the "Lake Erie" chapter.

2.7 DATA ON WILDLIFE

No data on residues in wildlife within the Detroit River, Lake St. Clair and St. Clair River system were obtained.

TABLE 2.6-1

Mercury concentrations in fillets of selected Lake St. Clair fishes collected in the fall of the year.

Species and Year	Number of fish	Average length (mm)	Average weight (g)	Total Mercury ppm 1/
Walleye				
1970	56	506	1214	2.83 (0.37)
1972	68	445	831	1.38 (0.16)
1973	77	485	1105	1.18 (0.10)
1974	60	501	1174	1.07 (0.10)
1975	99	497	1128	1.03 (0.10)
1976	30	497	1271	0.78 (0.20)
Rock Bass				
1970	45	185	164	1.24 (0.27)
1972	40	174	121	0.49 (0.08)
1973	36	178	126	0.37 (0.07)
1974	50	209	211	0.37 (0.06)
Yellow Perch				
1970	45	198	106	1.22 (0.17)
1973	45	191	91	0.31 (0.08)
1974	43	228	158	0.28 (0.04)
Channel catfish				
1970	15	538	1867	1.62 (0.45)
1972 2/	9	363	519	0.37 (0.19)
1973 2/	8	461	1023	0.35 (0.08)
1974 2/	20	490	1135	0.35 (0.04)

1/ Concentrations expressed as elemental mercury in wet weight of tissue with 95% confidence interval in parentheses

2/ Whole fish.

Source: U.S. Fish and Wildlife Service
Great Lakes Fishery Laboratory

TABLE 2.6-2

Mean concentrations (μg/g, fillets) of mercury in Lake St. Clair fishes (Ontario Ministry of Environment data).

Species	1970	1971	1972	1973	1974	1975	1976	1977
Walleye	2.3	1.8	1.4	1.1	1.2	0.8	0.9	1.0
Northern Pike	4.4	4.9	4.4	2.7	2.5	1.8	1.6	1.9
Channel Catfish	1.4	1.7	1.3	1.0	0.9	0.7	0.8	0.4
White Bass	2.2	2.4	1.9	1.2	0.8	0.7	0.9	0.8
Bluegill	2.2	1.7	1.2	0.9	0.8	0.7	0.6	-
Rock Bass	-	4.1	2.2	1.1	1.1	0.8	1.1	0.8
Carp	-	1.6	1.1	0.9	0.7	0.6	0.8	0.6
Yellow Perch	-	-	-	0.6	0.4	0.6	1.0	0.5

TABLE 2.6-3

MERCURY ANALYSES - LAKE ST. CLAIR FISH TISSUE
LAKE ST. CLAIR MERCURY DATA SUMMARY - 1976

ONTARIO MINISTRY OF THE ENVIRONMENT

SPECIES	N	MEAN (μg/g)	MAX (μg/g)	MIN (μg/g)	STD. DEV. (μg/g)	MEAN WT.(gm)	%≥.5 μg
Walleye	246	0.93	3.00	0.11	0.612	1270	66.3
R. Bass	80	1.09	3.40	0.17	0.533	213	87.5
W. Bass	62	0.91	2.03	0.10	0.486	618	77.4
Y. Perch	14	0.98	2.86	0.11	0.824	152	71.4
S.M. Bass	28	1.19	3.67	0.24	0.776	790	92.9
W. Sucker	23	0.83	1.90	0.06	0.558	1065	69.6
Carp	104	0.79	1.50	0.16	0.320	3440	76.0
C. Catfish	56	0.77	1.89	0.35	0.300	2200	82.1
Pike	50	1.64	3.80	0.20	0.819	2370	92.0
Muskie	4	0.79	1.80	0.24	0.693	4630	50.0
L.M. Bass	16	1.34	2.10	0.89	0.405	590	100.0
B. Crappie	48	0.69	2.00	0.22	0.417	253	62.5
P'Seed	4	0.57	0.77	0.35	0.183	175	75.0
Bluegill	7	0.63	0.80	0.47	0.139	198	71.4

TABLE 2.6-4

ORGANIC ANALYSES - FISH TISSUE FROM LAKE ST. CLAIR, DETROIT RIVER, ST. CLAIR RIVER

YEAR	LOCATION	SPECIES	NO. SAMPLES	AVE WT or LENGTH	% LIPIDS	CONCENTRATIONS - Average ppm						INFORMATION SOURCE
						ΣDDT	HEPTACHLOR EPOXIDE	DIELDRIN	ENDRIN	CHLORDANE	PCB	
1970-75	Lake St. Clair	Tables 2.6-5 2.6-6									✓	92
1972	St. Clair River	Tables 2.6-6 2.6-7									✓	92
1975	Tremblay Creek	Minnows	100								0.61 (0.1-1.0)	92
1975	Tremblay Creek	Spottail Shiners	4	65±5mm	3.4±1.9	0.08±0.05	0.002±0.001	ND	ND	ND	0.28±0.21	73
1976	Lake St. Clair	S.M. Bass	6		2.45 (1.2-3.6)	0.76 (0.1-1.2)		0.09 (0.03-0.14)			2.1 (0.4-3.1)	93
1976	Mitchell's Bay	Y. Walleye	10		3.8 (1.6-7.2)	0.18 (0.005-0.42)		0.004 (0.01-0.15)			0.7 (0.3-2.0)	93
1977	Detroit River	Carp (See Tables 2.6-8, 2.6-9)	10									94
		Pike	10									

TABLE 2.6-5

SOURCE: Lake St. Clair (Ref. 92)

DATE	FISH SPECIES	NUMBER OF FISH	WEIGHT IN KG RANGE OR (AVERAGE)	PCB LEVEL IN ppm MEAN	PCB LEVEL IN ppm RANGE
1970	Large Mouth Bass	6	(0.56)	1.3	-
	Mooneye	12	(0.31)	1.9	-
	Yellow Perch	3	(0.11)	0.12	-
	Quillback Sucker	6	(1.32)	0.31	-
	Redhorse Sucker	8	(0.93)	0.01	-
	White Sucker	10	(1.30)	0.29	-
1971	Large Mouth Bass	5	(0.63)	0.83	-
	Rock Bass	10	(0.23)	0.10	-
	Carp	8	(3.68)	0.72	-
	Catfish	6	(2.02)	2.3	-
	Black Crappie	13	(0.20)	0.07	-
	Long-nose Gar	12	(0.72)	1.5	-
	Yellow Perch	11	(0.06)	0.11	-
	Quillback Sucker	9	(1.24)	0.18	-
	Redhorse Sucker	8	(0.70)	0.19	-
	Pickerel	10	(0.59)	0.10	-
	Pickerel	46	0.15 - 2.4	0.83	0.25 - 3.1
1972	Coho Salmon	1	-	2.7	-
	Perch	24	0.07 - 0.16	0.14	0.07 - 0.25

Levels are generally similar to those for Lake Huron. Pickerel levels run as high as 3.1 ppm, but average less than 1. One Coho salmon had a level of 2.7 ppm.

TABLE 2.6-6

(Ref. 92)

LAKE ST. CLAIR - ST. CLAIR RIVER

Year	Species	Location	No. of Samples	Mean Wt. (grams)	PCB Concentration (ppm) mean	max.	min.
1970	Largemouth Bass	Lake St. Clair	6	564	1.3		
	Yellow Perch		3	108	0.12		
	Quillback Sucker		6	1319	0.31		
	Rednose Sucker		8	928	0.01		
	White Sucker		10	1298	0.29		
	Mooneye		12	306	1.9		
1971	Walleye	Lake St. Clair	10	591	0.10		
	Largemouth Bass		5	632	0.83		
	Rock Bass		10	230	0.10		
	Yellow Perch		11	59	0.11		
	Quillback Sucker		9	1244	0.18		
	Rednose Sucker		8	698	0.19		
	Bluegill		25	172	0.06		
	Bowfin		10	1367	0.05		
	Brown Bullhead		12	427	0.11		
	Black Crappie		13	199	0.07		
	Carp		8	3676	0.72		
	Catfish		6	2016	2.3		
	Freshwater-Drum		12	519	0.17		
	Longnose Gar		12	723	1.5		
	Pumpkinseed Sunfish		22	104	0.11		
1971	Walleye		46		0.83	3.0	0.25
1972	Coho Salmon	St. Clair River	4	120	2.9	4.7	1.4
	Rainbow Trout		2	490	2.9	3.8	1.9
	Yellow Walleye		1	594	0.16		
	Smallmouth Bass		3	493	0.30	0.52	0.10
	White Bass		5	500	7.6	12	4.3
	Perch		12	130	0.16	0.22	0.08
	Pike		11	190	2.2	6.8	0.11
	N. Rednose Sucker		4	898	0.74	1.3	0.34
	White Sucker		20	881	1.2	2.8	0.14
1972	Perch	Lake St. Clair	24	107	0.14	0.25	0.07
1972	Coho Salmon	Lake St. Clair	1		2.7		
1973	Rainbow Trout	Lake St. Clair	1	2724	1.0		
1975	Minnow	Tremblay Creek	100		0.61	1.0	0.1

TABLE 2.6-7

PCBS IN TISSUE OF FISH FROM THE ST. CLAIR RIVER

(Ref. 92)

DATE	FISH SPECIES	NUMBER OF FISH	WEIGHT IN KG RANGE OR (AVERAGE)	PCB LEVEL IN ppm MEAN	PCB LEVEL IN ppm RANGE
1972	Redhorse Sucker	4	0.71 - 1.1	0.74	0.34 - 1.3
	Common White Sucker	20	0.42 - 1.2	1.2	0.14 - 2.8
	Small Mouth Bass	3	0.29 - 0.60	0.30	0.10 - 0.52
	Pickerel	1	0.59	0.17	-
	Coho Salmon	4	0.89 - 1.2	2.9	1.4 - 4.7
	White Bass	5	0.33 - 0.67	7.6	4.3 - 12.
	Pike	11	0.96 - 3.0	2.2	0.11 - 6.8
	Rainbow Trout	2	0.42 - 0.56	2.9	1.9 - 3.8
	Perch	12	0.06 - 0.15	0.16	0.06 -0.24

PCB levels in St. Clair River fish are somewhat elevated in comparison with those from Lakes Huron and St. Clair. This is possibly attributable to exposure to PCBs from industrial and municipal effluents. Only Pike and Bass show levels at or above the acceptable limit, but other species - Coho salmon and Rainbow trout - have levels of some concern.

TABLE 2.6-8
(Ref. 94)
POLYNUCLEAR AROMATIC HYDROCARBONS IN
GREAT LAKES FISH IDENTIFIED BY MASS SPECTROMETRY

PAH	Hamilton Harbor Carp	Hamilton Harbor Pike	Detroit River Carp	Detroit River Pike
1. naphthalene	x	x		x
2. 2-methyl naphthalene	x	x		x
3. 1-methyl napthtalene	x	x		x
4. biphenyl	x	x		x
5. acenaphthene		x		x
6. dimethyl naphthalene		x		x
7. fluorene		x		x
8. anthracene	x	x		x
9. phenanthrene	x	x		x
10. 1-phenyl naphthalene	x	x		x
11. 1-methyl phenanthrene	x	x		x
12. 1-methyl anthracene	x	x		x
13. 2-methyl anthracene	x	x		x
14. 2-methyl phenanthrene	x	x		x
15. 9-methyl anthracene				x
16. fluoranthrene	x	x		x
17. pyrene	x	x		x
18. 1, 2-benzofluorene		x		x
19. 2, 3-benzofluorene		x		x
20. chrysene	x	x		x
21. benzo-(a)-pyrene		x		x
22. perylene		x		x
23. dibenz-(a, h)-anthracene	x	x		x
24. coronene	x	x		x

x detected

Other compounds scanned for but not found include 4 methyl biphenyl, 3, 6 dimethyl phenanthrene, 9, 10 dimethyl anthracene, 1-methyl pyrene, 1, 1 binaphthyl, benzo-(e)-pyrene, 9, 10 diphenyl anthracene, ananthrene, benzo-(g, h, i)-perylene, picene, and dibenz pyrenes.

TABLE 2.6-9

(Ref. 94)

QUANTITATION OF PAH IN GREAT LAKES FISH
FLUORESCENCE DETECTION USING LIQUID CHROMATOGRAPHY

Fish	Polynuclear Aromatic Hydrocarbons ng/kg fresh weight fillet			
Detroit Carp	Perylene	Benzo-(k)-fluoranthene	Benzo-(a)pyrene	Coronene
1	16	10	40	80
2	nd	nd	nd	60
3	40	14	40	nd
4	26	10	40	40
5	nd	nd	nd	nd
6	nd	nd	nd	nd
7	nd	nd	nd	120
8	nd	nd	nd	80
9	nd	nd	nd	nd
10	nd	nd	nd	nd
Detroit Pike				
1	34	26	40	20
2	20	14	14	40
3	18	8	20	44
4	20	8	20	44
5	68	26	128	290
6	18	10	24	40
7	20	6	30	30
8	nd	nd	nd	nd
9	46	24	70	120
10	52	26	100	120

nd = non detectable

detection limits: 5 ng/kg perylene, benzo-(k)-fluoranthene, benzo-(a)-pyrene
20 ng/kg coronene

nearshore areas identified with high metal concentrations in water were Tawas City (copper), Presque Ile (copper), Saginaw Bay (copper and zinc), and the French River area (copper and nickel). Contamination of waters in the French River area was presumed to be a result of atmospheric fallout from the Sudbury smelting operations. PLUARG in its 1978 Report to the Commission (9) reported the following Lake Huron open water trace element concentrations (μg/L) mercury ($\leq$0.05); lead ($\leq$1.0); chromium ($\leq$0.2); cadmium ($\leq$0.2); copper ($\leq$2.0); zinc ($\leq$7.0); selenium ($\leq$0.1); and, arsenic ($\leq$0.6).

Organic Contaminants

Results of surveys for organic contaminants in the open waters of Lake Huron are shown in Table 3.1-5. Several unidentified compounds were observed by Strachan (14) in Lake Huron waters during 1973. Estimated quantities of phthalates, fatty acids and hydrocarbons were reported. In 1974, Glooschenko, Strachan and Sampson (12) analyzed Lake Huron waters obtained from 18 different sites, for PCBs, and organochlorine and organophosphorus pesticides. No compounds were detected in filtered waters above the quantification limits shown in Table 3.1-6. Detectable amounts of lindane were found in each of the water samples, and trace amounts of both heptachlor and dieldrin were found in the middle of Lake Huron. A station off Goderich, Ontario showed traces of p,p' - DDE.

The Upper Lakes Reference Group, detected measureable quantities of PCBs and phthalate esters in Saginaw Bay (Table 3.1-7) during 1974. The Reference Group found the PCB concentration in open waters of Lake Huron to be less than the 10 ng/L detection limit. Some nearshore areas contained detectable amounts of DDT during the Reference Group study. Also the Reference Group expressed concern about the high phenol levels at the mouth of the Spanish River and within the St. Mary's River.

Additional data of organic contaminant levels on Lake Huron and tributary waters have been reported by the Michigan Department of Natural Resources (Table 3.1-8) (reference 97) and by the EPA study to detect previously unrecognized pollutants in surface waters (Table 3.1-5) (reference 18).

Recently, within the proceedings of a conference on PBBs (165), the levels of PBBs in the Pine River were reported. The observed levels are shown in Table 3.1-9.

A PLUARG Task C report (170), published in 1978, shows the levels of pesticides which were detected in three watersheds within the Lake Huron Basin. Within Tables 1.1-11 to 1.1-20, the determined pesticide levels are summarized, where AG-3 refers to the Au Sable River watershed, AG-6 refers to the Maitland River watershed and AG-14 refers to the Saugeen River watershed. The tables are located in the section on Lake Erie.

TABLE 3.1-1

HEAVY METAL CONCENTRATIONS IN LAKE HURON WATERS

ppb (μg/L)[a]

Date	Station(s)	No. Samples	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn	Source
1970-71	Whole Lake See Figures 3.1-1 to 3.1-2	387							0.17±.11							4
1973-77	Alpena Water Intake	10	<1-.4	<.1-1	2-4		10-40[(b)]	<1-8	<.1-.5		6-35[(b)]	<2	<1-1[(b)]		1-17[(b)]	97
1973-77	Bay City Water Intake (Saginaw Bay)	10	<1-4	<.1-1	2-16		2-11[(b)]	<1-9	<.1-.4		7-24	<2	<1-1[(b)]		4-28	97
1973-77	Saginaw Midland Water Intake	10	<1-2	<.1-1	<1-2		2-12	<1-6	<.1-.4		3-8	<2	<1-1[(b)]		4-28	97
1975	Detour	3	.8	<.04	<.3		.9±.2	.4±.3			<.9				<2.5	98
1975	Cheboygan	3	.9±.1	<.03	.4±.05		1.0±.5	.4±.2	<.02		<.8				<1.9	98
1975	Calcite															
1975	Calcite	3	.9±.3	<.04	.3		2.5±1.3	.4±0	<.02		<.8				<2.3	98
1975	Presque Ile	3	.8±.1	<.04	<.3		.7±.2	.4±.4	<.02		<.9				<1.6	98
1975	Alpena	3	.8±.2	.12±.16	<.3		1.4±.5	.7±.4	<.02		<.8				<3.0	98
1975	Harrisville	3	.8±.3	.15±.04	<.3		3.4±3.2	1.0±.7	<.02		<.9				4.9±3.7	98
1975	Tawas	3	.9±.3	.14±.07	.8±.9		2.2±.1	.8±.2			.9±.1				2.4±.9	98
1975	Saginaw Bay	5	.8±.2	.1±.05	.4±.04		1.7±.4	.5±.2	<.03		1.0±.1				<1.3	98
1975	Harbor Beach	3	.7-.1	.1±.07	.5±.1		1.4±.7	.7±.1	<.04		1.4±.4				2.5±.4	98
1975	Lexington	3	.7±.1	.04±.01	.4±.02		1.1±.8	.7±3	<.02		0.9±.1				2.2±.6	98

(a) "Total" (unfiltered) metal concentrations unless otherwise specified.

(b) Dissolved (filtered) water samples

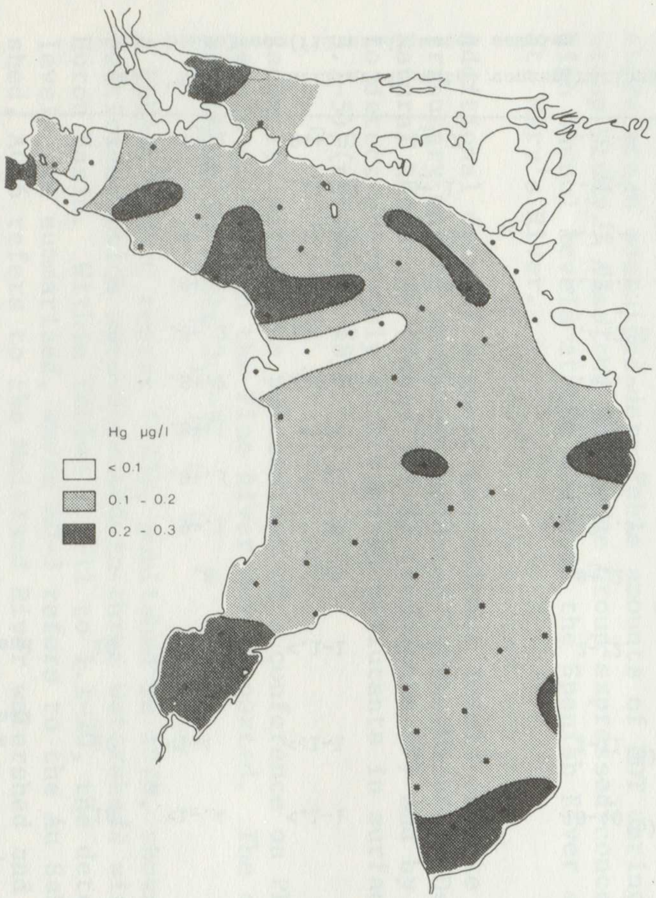


FIG. 3.1-1 The average distribution of total mercury in the surface waters of Lake Huron (1970-1971). Dots represent sampling stations.

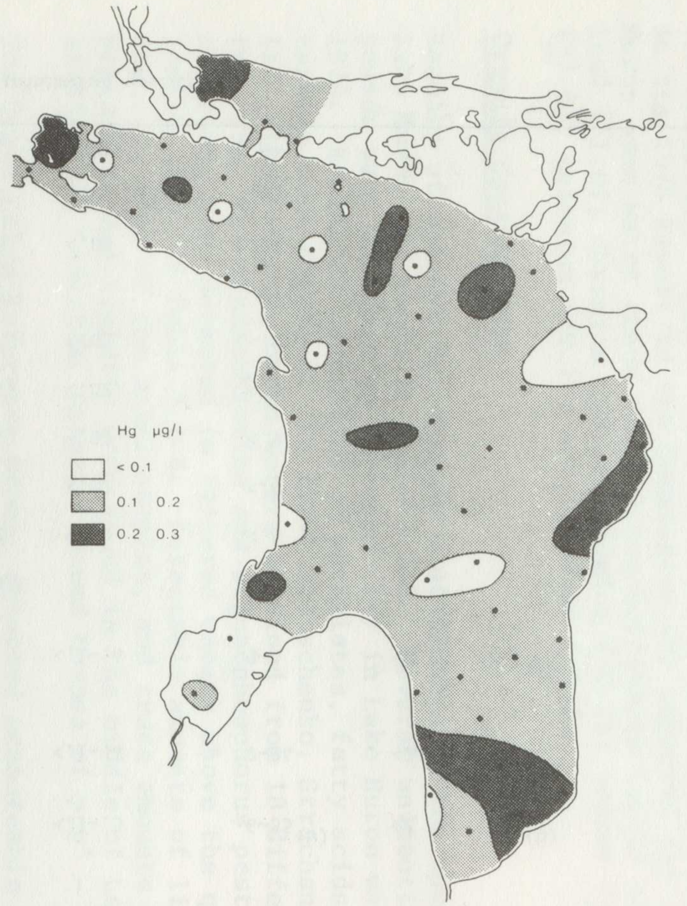


FIG. 3.1-2 The average distribution of total mercury in the bottom waters of Lake Huron (1970-1971). Dots represent sampling stations.

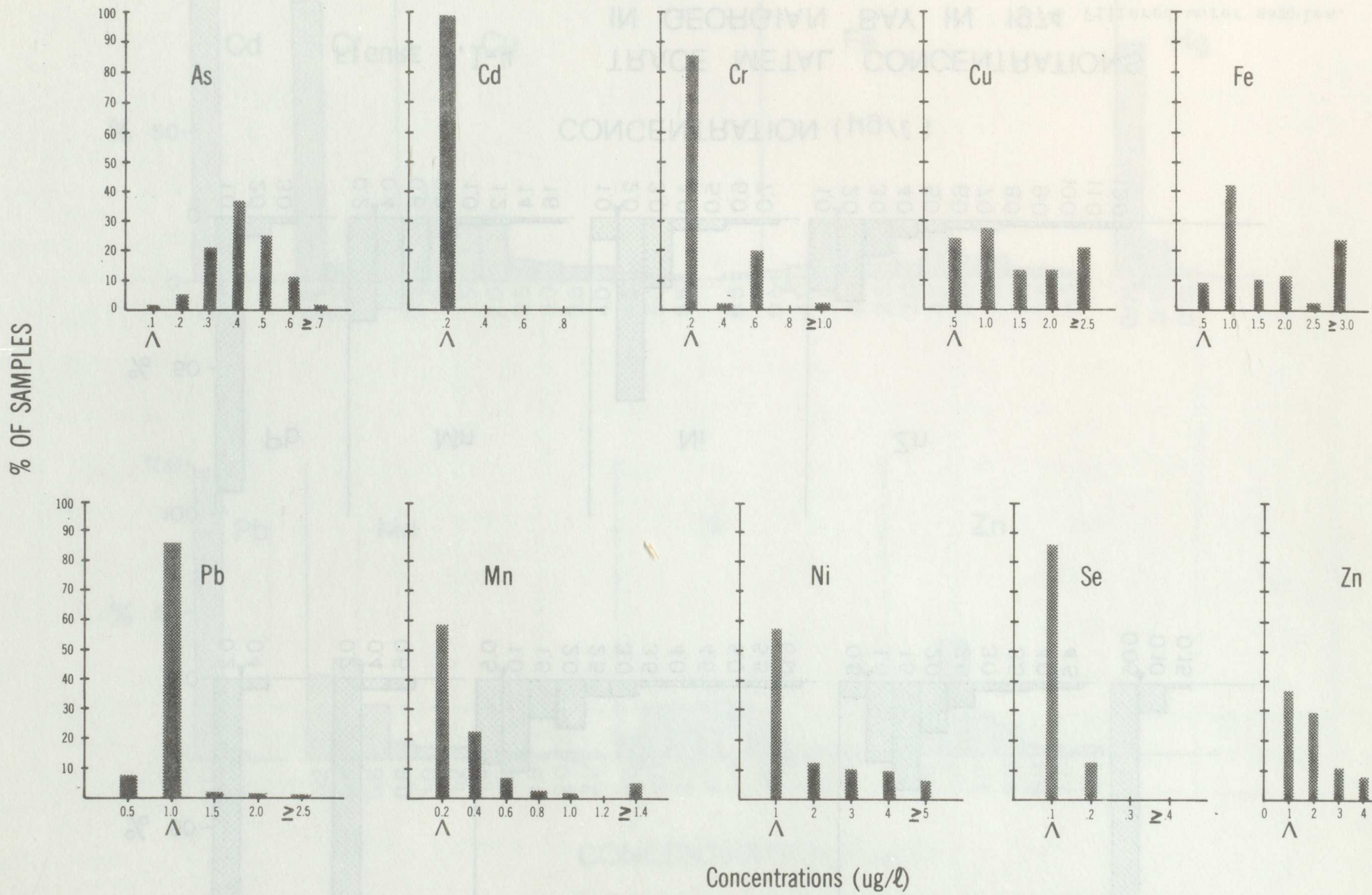


FIGURE 3.1-3 TRACE METAL CONCENTRATIONS IN LAKE HURON IN 1974 (3,5)
Filtered epilimnion water samples. Data from all segments have been combined.
The caret denotes the analytical detection limit.

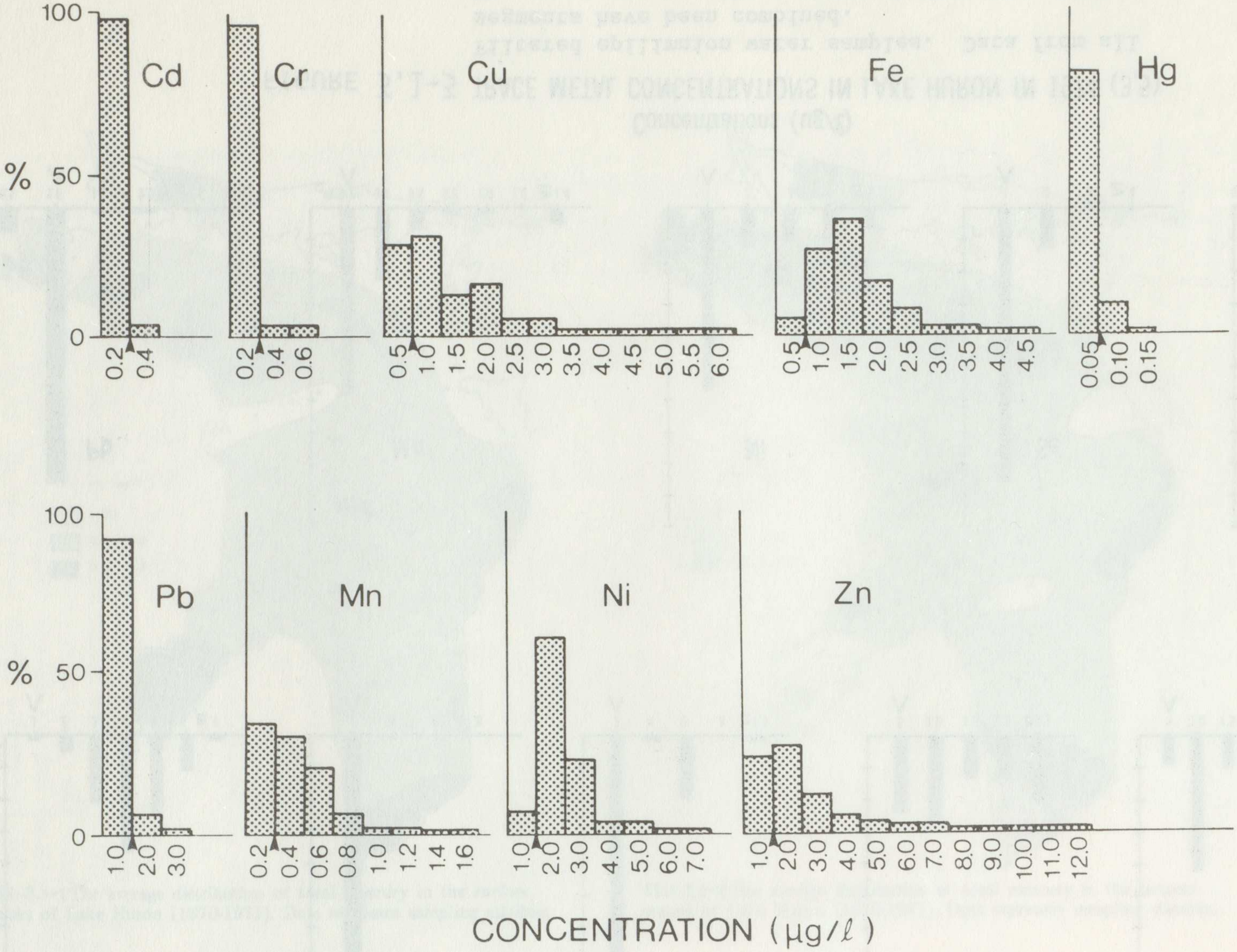


FIGURE 3.1-4 TRACE METAL CONCENTRATIONS IN GEORGIAN BAY IN 1974 Filtered water samples. The caret denotes the analytical detection limit.

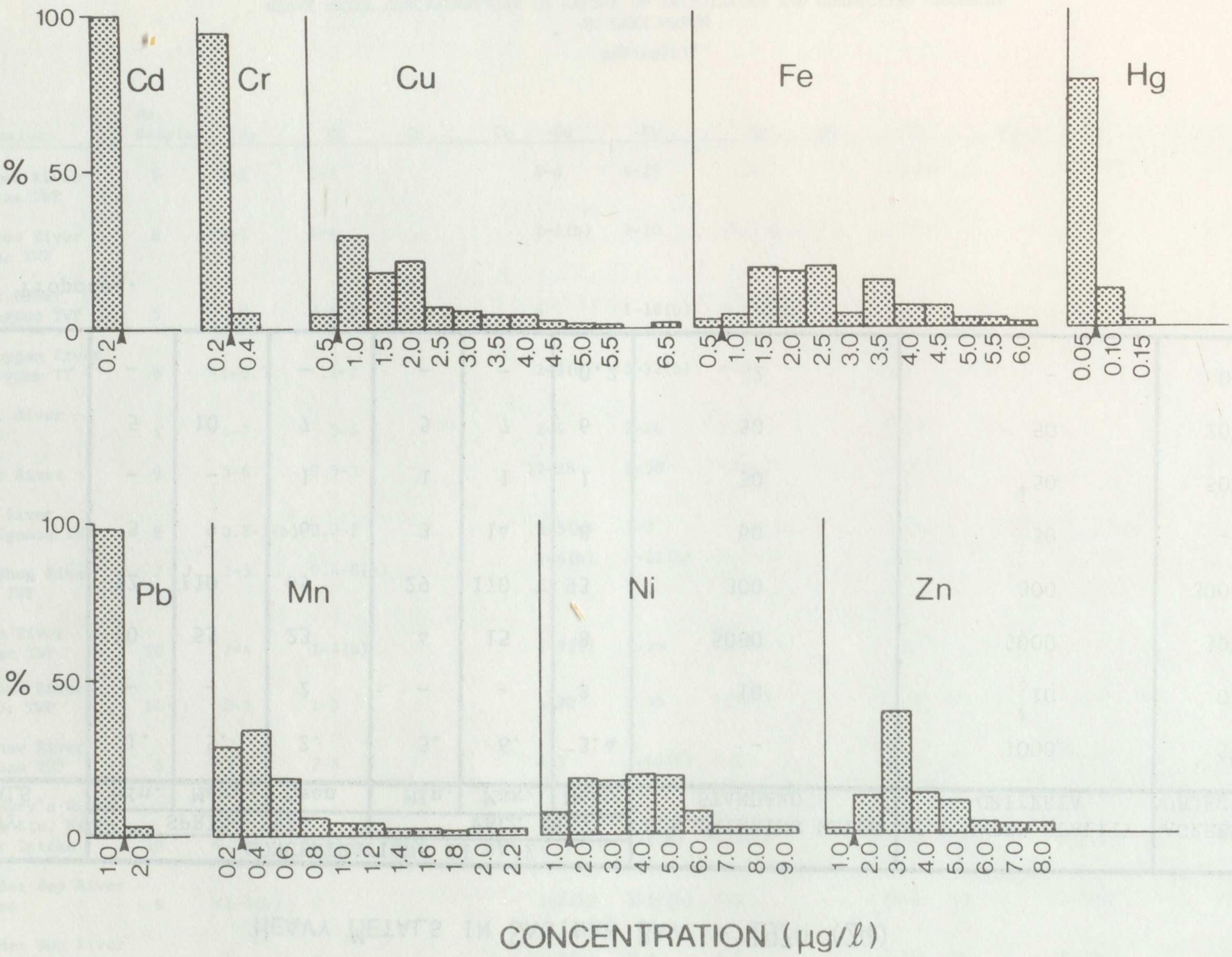


FIGURE 3.1-5 TRACE METAL CONCENTRATIONS IN THE NORTH CHANNEL IN 1974

Filtered water samples. The caret denotes the analytical detection limit.

TABLE 3.1-2

Heavy Metals in Saginaw Bay - 1974 (24)

HEAVY METALS	CONCENTRATIONS IN µg/ℓ						U.S. DRINKING WATER STANDARD	U.S. WATER QUALITY CRITERIA	AGREEMENT OBJECTIVE
	SPRING 1974			FALL 1974					
	Min.	Max.	Mean	Min.	Max.	Mean			
Cu	1.	5.	2.	3.	6.	3.4	-	1000	5[a]
Cd	-	-	2	-	-	2	10	10	0.2[a]
Zn	10	55	23	4	15	8	5000	5000	30[a]
Fe	32	110	65	29	170	93	300	300	300
Mn	3	9	6	3	14	8	50	50	-
Cr	-	-	1	1	1	1	50	50	50[a]
Pb	5	10	7	5	7	6	50	50	20[a]
Hg	-	-	-	-	-	0.2	2	-	0.2[a]

a. Proposed.

TABLE 3.1-3

HEAVY METAL CONCENTRATIONS IN WATERS OF TRIBUTARIES AND CONNECTING CHANNELS TO LAKE HURON

ppb (μg/1)[a]

Date	Stations	No. Samples	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn	Information Source
1973-77	Au Gres River Au Gres TWP	7	1-2	1-3			4-6	4-27	<.2		23-27	<1	<1-7(b)		12-59(b)	97
1973-77	Au Gres River Oscoda TWP	8	<1-1	1-4			1-4(b)	7-10	<0.1-0.2		9-10	<1	<1-1(b)		1-12(b)	97
1973-77	Black River Lexington TWP	5	2-9	0.4-2			4	1-18(b)	<.1-1.5		25-26	<1	<1		10-21(b)	97
1973-77	Cheboygan River Cheboygan TY	8	<1-0.3	<.1-2			2-3(b)	<1-22(b)	<.2		10-11	<1	<1-1(b)		8-15(b)	97
1974-77	Flint River Flint	4	4-7	3-4			2-4	2-26	<.2		<10-20	<1	<1		4-16	97
1973-77	Flint River	9	5-6	0.5-3			12-28	8-58	<.2-.2		24-86	<1	<1-1(b)		80-220	97
1973-77	Pine River St. Ignace TWP	9	0.3-2(b)	0.2-2			2-5(b)	1-8	<.1-.3		8-10	<1-1(b)	<1-3.5(b)		14-90	97
1974-77	Pinnebog River Hume TWP	7	2-5	0.4-8(b)			4-6(b)	2-21(b)	<.1-.5		22-26	<1	<1-4(b)		18-23	97
1973-77	Rifle River Arenac TWP	10	2-4	1-4(b)			1-7(b)	5-16	<.1-.5		14-17	<1	<1-7(b)		6-21	97
1973-77	Saginaw River Bangor TWP	14	2-3	1-3			5-20	2-30	<.1-.7		24-34	<1-2(b)	<1-5(b)		20-36	97
1974-77	Saginaw River Saginaw TWP	5	3-4	2-5			6-7	5-40(b)	<.2		29-36	<2	<1-1(b)		25-210	97
1973-77	St. Mary's River Sault Ste. Marie Water Intake	10	<.2-1	<.1-.5	<1-28		<1-11(b)	<1-8(b)	<.1-.8		2-7	<2	<1-1(b)		16-260	97
1973-77	Thunder Bay River Alpena	9	<1-4(b)	2			1-6(b)	8-19(b)	<.2		6-10	<2	<1-5(b)		6-56(b)	97
1973-77	Thunder Bay River Long Rapids TWP	6	<1-.4	1			1-7(b)	7-8	<.2		14-15	<2	<1-1(b)		10-16	97
1973-77	Van Etten Cr. Oscoda TWP	8	<1-1	1-2			1-4(b)	3-10(b)	<.2-0.6		9-12	<2	<1-1(b)		6-10(b)	97

(a) "Total" (unfiltered) metal concentrations unless otherwise specified.

(b) Dissolved (filtered) water samples.

TABLE 3.1-4

TRIBUTARY INPUTS TO LAKE HURON SUB-BASINS

JULY 1973 - JUNE 1975

Parameter	Mean Loading (kg/d)								
	North Channel And St. Marys River			Georgian Bay			Main Lake Huron		
	Sampled Basin	Unsampled Basin	Total	Sampled Basin	Unsampled Basin	Total	Sampled Basin	Unsampled Basin	Total
Alkalinity ($CaCO_3$)	a	a	a	a	a	a	5,010,000	829,000	5,840,000
Arsenic	366	15.3	382	636	36.0	672	251	29.6	280
Barium	1,963	61.2	2,023	2,190	144	2,330	2,700	385	3,090
BOD_5 (at 20°C)	199,000	2,460	201,000	55,400	5,780	61,200	136,000	17,700	154,000
Cadmium	647	30.6	678	1,090	71.9	1,160	287	57.8	345
Calcium	333,000	23,000	356,000	823,000	111,000	934,000	2,580,000	401,000	2,980,000
Carbon, Total Organic	242,000	10,700	253,000	423,000	31,600	455,000	932,000	143,000	1,080,000
Chem. Oxygen Demand	715,000	35,200	750,000	1,130,000	82,700	1,210,000	1,280,000	178,000	1,450,000
Chloride	155,000	6,120	161,000	215,000	18,000	233,000	1,410,000	187,000	1,600,000
Chromium	410	23.0	433	849	54.1	903	236	38.0	274
Copper	1,320	38.2	1,360	1,540	89.8	1,630	645	79.4	724
Cyanide	180	7.64	187	261	18.0	279	66.7	12.6	79.3
Fluoride	3,087	130	3,220	4,040	431	4,470	9,000	1,310	10,300
Iron	12,700	995	13,700	11,500	1,258	12,800	60,400	3,440	63,900
Lead	1,020	33.7	1,050	1,440	89.8	1,530	619	91.1	710
Magnesium	73,800	3,060	76,900	195,000	36,000	231,000	813,000	128,000	941,000
Manganese	1,800	76.4	1,880	1,640	180	1,820	1,100	194	1,290
Mercury	3.20	0.130	3.33	4.10	0.250	4.35	2.80	1.59	4.39
Nickel	1,090	45.8	1,140	2,060	108	2,170	638	104	742
Nitrogen, Total as N	21,000	1,070	22,100	27,400	2,540	29,900	91,000	16,800	108,000
Nitrogen, Organic as N	11,600	750	12,400	17,800	1,310	19,100	33,700	4,310	38,100
Nitrogen, NH_3 as N	2,580	91.8	2,670	1,600	126	1,730	5,900	499	6,400
Nit., NO_3 + NO_2 as N	6,700	340	7,040	8,020	1,100	9,120	51,400	12,000	63,400
Oil - Grease	34,900	1,220	36,100	40,600	2,950	43,600	83,300	11,000	94,300
Pesticides	0.005	0.001	0.006	0.067	0.004	0.071	0.106	0.053	0.158
Phenols	132	5.36	138	163	10.8	174	275	68.8	344
Phos., Total as P	2,550	76.4	2,630	1,830	180	2,010	5,480	694	6,170
Phos., Reactive as P	1,060	53.6	1,110	1,180	36.0	1,220	2,620	341	2,960
Phthalates	a	a	a	a	a	a	174	b	174
PCB	0.100	0.003	0.103	0.059	0.007	0.067	1.39	0.523	1.91
Potassium	36,700	2,600	39,300	59,000	6,820	65,800	89,700	14,700	104,000
Selenium	32.0	1.86	33.8	72.2	5.17	77.4	29.3	4.04	33.4
Silicate, Reac. as SiO_2	133,000	6,800	140,000	143,000	14,000	157,000	283,000	35,800	318,000
Sodium	105,000	4,600	109,000	152,000	14,400	166,000	742,000	92,500	834,000
Solids, Total	2,080,000	138,000	2,210,000	5,130,000	539,000	5,670,000	17,500,000	2,530,000	20,000,000
Solids, Dissolved	1,740,000	116,000	1,850,000	4,630,000	496,000	5,120,000	15,300,000	2,330,000	17,700,000
Solids, Particulate	328,000	21,400	349,000	504,000	43,100	547,000	2,050,000	135,000	2,190,000
Sulfate as SO_4	542,000	18,400	561,000	681,000	46,700	728,000	1,750,000	294,000	2,040,000
Zinc	873	49.7	922	1,570	108	1,680	917	95.8	1,010

The totals shown above represent all available data. However, some discharges were not sampled for all parameters, and some analytical techniques varied between the two jurisdictions.

a. Not sampled
b. Below limits of detectability

TABLE 3.1-5

ANALYSES FOR ORGANIC CONTAMINANTS IN THE WATERS AND TRIBUTARIES OF LAKE HURON

LOCATION	SAMPLING PERIOD	NO. OF SAMPLES	ORGANIC SUBSTANCES DETECTED AND QUANTIFICATION (µg/L)	QUANTIFICATION LIMIT (µg/L)	SOURCE
Open Lakes	1973	6	Hydrocarbons - 3-8 (mostly acyclic - C_{20}-C_{30}) Fatty Acids - 0.1-1 Phthalates - 0.8-3	.1 .1 .1	14
Saginaw Bay	1974	24	(See Table 3.1-7)		96
Detour, Cheboygan, Presque Isle, Lexington	1974		DDT (0.001-0.004)	.001	96
Entire Lake	1974	18 sites	Lindane - Trace	.005	12
Middle Lake Huron	1974		Heptachlor - Trace Dieldrin - Trace (See Table 3.1-6 for compounds sought)	Table 3.1-6	12
Spanish River Mouth	1974		Phenol - ave. - 3 - max. - 14		96
St. Mary's River	1974		Phenol - .3 km from Algoma Steel - 24 - 3.2 km downstream - 10		96
Saginaw River (Bay City)	1976		Dimethyl sulfide - 1 Dimethoxy methane - 3 Chloroform - 1 Dimethyl disulfide - 1 Methyl Palmitate - 6 Methyl Stearate - 3 Terpene - C_{15} - 1 Camphor - (Trace) Dibutyl phthalate - 1 Diethyl hexylphthalate- 1		18

TABLE 3.1-6

QUANTIFICATION LIMITS FOR ORGANOCHLORINE AND ORGANOPHOSPHORUS COMPOUNDS IN STUDY OF LAKES SUPERIOR AND HURON BY GLOOSCHENKO, STRACHAN AND SAMPSON (12)

COMPOUND	Quantification Limit WATER PPB	SESTON, NG	SEDIMENT, PPM
Lindane	0.005	1	0.001
Heptachlor	0.005	1	0.001
Heptachlor epoxide	0.005	1	0.001
Aldrin	0.005	1	0.001
Dieldrin	0.005	1	0.001
Endrin	0.01	10	0.001
p,p-DDE	0.005	1	0.001
p,p-TDE	0.005	1	0.001
p,p-DDT	0.005	1	0.001
o,p-DDT	0.005	1	0.001
α-Chlordane	0.01	5	0.005
β-Chlordane	0.01	5	0.005
α-Endosulfan	0.01	10	0.01
β Endosulfan	0.01	10	0.01
p,p-Methoxychlor	0.01	50	0.05
PCBs	0.1	10	0.01
Phorate	0.003	50	0.01
Diazinon	0.005	100	0.02
Disulfoton	0.003	50	0.01
Ronnel	0.005	100	0.02
Methyl Parathion	0.005	100	0.02
Malathion	0.005	100	0.02
Parathion	0.005	100	0.02
Crufomate	0.025	500	0.1
Methyl Trithion	0.01	200	0.04
Ethion	0.005	100	0.02
Carbophenothion	0.01	200	0.04
Imidan	0.05	1000	0.2
Azinphosmethyl	0.05	1000	0.2
Azinphosethyl	0.05	1000	0.2
Phosphamidon	0.03	500	0.1
Dimethoate	0.005	100	0.02
Fenitrothion	0.005	100	0.02

TABLE 3.1-7

ORGANICS IN SAGINAW BAY - 1974 (24)

PARAMETER	CONCENTRATIONS IN ng/ℓ			PROPOSED AGREEMENT OBJECTIVES
	SAGINAW RIVER	INNER BAY	OUTER BAY	
Arochlor 1242	70	10	Not Found	-
Arochlor 1254	10	3	Not Found	-
Arochlor 1260	<10	<10	<10	-
Total PCB	80-90	13-23	0-10	1[a]
Dieldrin	0.8	0.5	0.6	1[b]
pp'DDT	<1	<1	<1	3[c]
DDE	<1	<1	<1	3[c]
DDD	<1	<1	<1	3[c]
Di(2-ethylhexyl)-phthalate	4 samples in bay ranged from <1000 to 1400; mean = 1300			600

a. This level may not be adequate to provide protection to certain predators, and could presently not be enforced because of insufficiently sensitive quantification limits.

b. Objective is for aldrin plus dieldrin.

c. Objective is for DDT plus metabolites.

TABLE 3.1-8

ORGANIC CONTAMINANT SURVEY OF LAKE HURON NEARSHORE WATERS AND TRIBUTARIES (a)

ORGANICS SOUGHT AND ANALYTICAL DETECTION LIMITS (μg/L)

Aldrin:	0.01	Silvex:	1.0
Dieldrin:	0.02	Endrin:	0.02
o,p-DDT:	0.01	Heptachlor:	0.005
p,p-DDT:	0.01	Lindane:	0.005
Dibutyl phthalate (DBP):	1.0	Methoxychlor:	5
Diethylhexyl phthalate (DEHP):	1.0	PCBs:	0.1
Toxaphene:	1.0	Aroclor 1242:	0.1
Chlordane:	0.1	Aroclor 1254:	0.1
2,4-D:	0.05	Aroclor 1260:	0.1

SAMPLING DATES	NO. SAMPLES	SAMPLING SITE	ORGANICS IN EXCESS OF ABOVE DETECTION LIMITS, CONCENTRATIONS, AND DATES NOTED
1975-76	6	City of Alpena Water Intake (Lake Huron)	DEHP - 1.6 μg/L (07/76)
1975-76	4	Bay City Water Intake (Lake Huron)	DEHP - 2.6 μg/L (01/76)
1975-76	4	Saginaw-Midland WTP Water Intake (Lake Huron)	DEHP - 1.9 μg/L (01/76)
1973-75	5	Au Gres River Au Gres TWP	p,p-DDT - 0.011 μg/L (08/74) DBP - 8.0 μg/L (12/73) - 0.6 μg/L (08/74)
1973-76	7	Au Sable River Oscoda TWP	p,p-DDT - 0.012 μg/L (08/74) DBP - 0.86 μg/L (08/74)
1976-77	4	Black River Port Huron	none
1973-76	7	Cheboygan River, Cheboygan	p,p-DDT - 0.016 μg/L (08/74) DEHP - 0.73 μg/L (08/74) PCBs - 0.5 μg/L (08/74)
1976-77	4	Flint River Albee TWP	none

TABLE 3.1-8 CONT'D

SAMPLING DATES	NO. SAMPLES	SAMPLING SITE	ORGANICS IN EXCESS OF ABOVE DETECTION LIMITS, CONCENTRATIONS, AND DATES NOTED
1973-75	6	Pine River St. Ignace TWP	o,p-DDT - 0.01 μg/L (08/74) p,p-DDT - 0.024 μg/L (08/74)
1974-75	4	Pinnebog River Hume TWP	none
1973-75	6	Rifle River Arenac TWP	DEHP - 11 μg/L (08/74) PCBs - 0.7 μg/L (08/74)
1973-77	11	Saginaw River, Bangor TWP	DEHP - 18 μg/L (08/74) - 1.2 μg/L (08/74) PCBs - 0.16 μg/L (08/74) Aroclor 1260 - 0.2 μg/L (05/76)
1973	1	Saginaw River Saginaw TWP	none
1974-76	5	St. Mary's River Saulte St. Marie	DEHP - 2.1 μg/L (01/76)
1973-76	8	Thunder Bay River Alpena	Aldrin - 0.01 μg/L (08/74) DBP - 2.0 μg/L (12/73) - 0.7 μg/L (08/74) DEHP - 2.3 μg/L (07/76)
1973-76	5	Van Etten Creek Oscoda TWP	p,p-DDT - 0.015 μg/L (08/74) DBP 0.17 μg/L (08/74) PCBs - 0.4 μg/L (08/74)

a) Michigan Department of Natural Resources

TABLE 3.1-9

PBB LEVELS OBSERVED IN THE PINE RIVER, MICHIGAN (165)

STATION	PBB CONCENTRATION μG/L		
	10/4/74	10/11/74	10/18/74
1.5 miles upstream from Michigan Chemical	<.1	<.1	<.1
St. Louis Reservoir - 5 m from outfall	0.9	9.8	1.1
St. Louis Reservoir - 50 m east of Michigan Chemical Corp.	0.4	0.5	1.3
Below St. Louis Dam	<0.1	<0.1	<0.1

3.2 DATA ON SEDIMENT QUALITY

Heavy Metals

The mean levels of trace metals in the sediments of Lake Huron, Georgian Bay and North Channel, as summarized by the ULRG (96), are shown in Tables 3.2-1 to 3.2-3. Mean levels of metals for recent (surface) and deeper precolonial sediments were determined by Kemp and Thomas (25), and these are shown in Table 3.2-4. Subsequently, Kemp and Thomas estimated the loadings of several elements to the lake sediments (Table 3.2-5).

Distributions of mercury and lead in Lake Huron sediments are shown in Figures 3.2-1 (96) and 1.2-8 (28). Figure 1.2-9 shows the lead profiles for Georgian Bay and Lake Huron sediment cores. Summaries of the lead analyses reported by PLUARG (28) are given in Tables 3.2-6 and 3.2-7. Extensive discussions for the interpretation of the Lake Huron sediment data are found in references 25, 28 and 96. For example, the ULRG has stated that "enrichment in Hg, Pb, Cu, Ni and Cd can be observed in the Saginaw Basin, reflecting point source discharges to Saginaw Bay." (Saginaw Bay data is shown in Table 3.2-8). "Mean Hg values (in the northern Manitoulin and Mackinac Basins) are high with no obvious anthropogenic Hg source." With regard to lead, Kemp and Thomas state that "the Pb enrichments in northern Lake Huron may be due to anthropogenic inputs and/or migration of Pb in the pure waters. Loading calculations indicate that atmospheric inputs of Pb could account for the Pb enrichment." The reader is referred to the above noted references for further information.

Analyses of Lake Huron harbor sediments are shown in Tables 3.2-9 and 3.2-10 (99).

Organic Contaminants

The results of studies on organic contaminants in Lake Huron sediments, by Glooschenko _et al_. (12) and by the Upper Lakes Reference Group (96), are summarized in Table 3.2-11. Levels of PCBs in Georgian Bay sediments ranged from less than the detection limit to 900 μg/kg (96). The ULRG reported that only one U.S. location - Harbor Beach - had PCBs detectable on sediments (18-27 μg/kg). 1976 data from U.S. EPA, however, reported PCB levels in the Saginaw River and Bay from <.1-22.9 mg/kg (100). Table 3.2-11 also contains information on PBB levels in Pine River sediments (165). Table 3.2-12 summarizes additional data from the ULRG report.

PLUARG in its 1978 report to the Commission (9), estimated an average of 4 μg/kg of PCBs in Lake Huron sediments. PLUARG data on pesticide levels in stream bed sediments of three Lake Huron watersheds (170) is found in Table 1.2-14 (in the Lake Erie chapter). The watersheds are described in Table 1.1-11.

TABLE 3.2-1 MEAN LEVELS OF TRACE METALS IN THE SEDIMENTS OF LAKE HURON

(Hg in μg/kg, all others in mg/kg)

SECTOR	No. of Samples	Hg $\overline{X}$ (s)	Pb $\overline{X}$ (s)	Cu $\overline{X}$ (s)	Zn $\overline{X}$ (s)	Ni $\overline{X}$ (s)	Co $\overline{X}$ (s)	Cr $\overline{X}$ (s)	Cd $\overline{X}$ (s)	V $\overline{X}$ (s)	Sr $\overline{X}$ (s)	As $\overline{X}$ (s)
Total Lake	197	217 (160)	49 (34)	32 (23)	62 (48)	39 (25)	17 (18)	32 (19)	1.4 (3.9)	44 (27)	66 (36)	1.09 (2.16)
Non-Depositional Zone	96	166 (123)	35 (28)	21 (20)	42 (35)	29 (24)	17 (21)	23 (15)	1.5 (5.2)	36 (23)	55 (38)	0.73 (0.90)
Total Basins	80	277 (177)	66 (35)	46 (18)	86 (50)	51 (21)	17 (13)	43 (17)	1.3 (0.8)	54 (27)	79 (28)	1.88 (3.5)
Sub-basins: Mackinac	11	229 (106)	67 (41)	47 (18)	111 (80)	52 (18)	14 (6)	65 (16)	1.4 (0.8)	67 (15)	70 (27)	2.60 (3.4)
Sub-basins: Manitoulin	42	286 (202)	70 (41)	51 (16)	92 (44)	54 (16)	17 (12)	43 (15)	1.3 (0.7)	54 (32)	90 (25)	1.72 (3.4)
Sub-basins: Alpena	2	82 (12)	59 (7)	47 (18)	87 (3)	57 (26)	11 (3)	43 (22)	1.7 (0.7)	65 (10)	33 (2)	-
Sub-basins: Saginaw	4	307 (159)	87 (19)	63 (19)	99 (28)	90 (39)	15 (4)	36 (7)	2.8 (1.8)	70 (12)	40 (13)	-
Sub-basins: Goderich	16	251 (131)	58 (12)	30 (16)	63 (37)	35 (17)	22 (21)	29 (11)	1.0 (0.5)	40 (23)	79 (26)	1.01 (2.4)
Sub-basins: Port Huron	5	438 (174)	38 (27)	42 (11)	50 (27)	43 (8)	14 (7)	36 (8)	1.0 (0.4)	56 (19)	74 (17)	-

TABLE 3.2-2 MEAN LEVELS OF TRACE METALS IN THE SEDIMENTS OF GEORGIAN BAY AND NORTH CHANNEL

(Hg in µg/kg, all others in mg/kg)

	SECTOR	No. of Samples	Hg	Pb	Cu	Zn	Ni	Co	Cr	Cd	V	Sr	As
			$\bar{X}$ (s)	$\bar{X}$ (s)	$\bar{X}$ (s)	$\bar{X}$ (s)	$\bar{X}$ (s)	$\bar{X}$ (s)	$\bar{X}$ (s)	$\bar{X}$ (s)	$\bar{X}$ (s)	$\bar{X}$ (s)	$\bar{X}$ (s)
	Total	171	222 (130)	43 (29)	43 (23)	102 (57)	100 (59)	21 (9)	132 (118)	1.47 (1.06)	67 (25)	115 (101)	4.16 (7.18)
	Non-Depositional Zone	76	184 (615)	34 (23)	35 (20)	77 (43)	79 (51)	19 (10)	114 (111)	1.21 (0.77)	63 (23)	128 (143)	4.21 (7.09)
	Total Basins	40	392 (1517)	67 (27)	60 (16)	146 (43)	119 (51)	24 (7)	176 (134)	2.01 (1.51)	77 (18)	124 (44)	7.19 (9.92)
Sub-basins	Nottawasaga	14	301 (570)	69 (26)	55 (13)	150 (42)	105 (46)	22 (6)	140 (99)	1.94 (0.89)	70 (9)	113 (61)	7.01 (7.00)
Sub-basins	Owen Sound Tr.	6	65 (45)	57 (31)	53 (14)	125 (44)	112 (48)	23 (8)	175 (162)	1.45 (0.46)	64 (6)	99 (25)	5.92 (4.72)
Sub-basins	Lion's Trough	2	4800 (6630)	100 (14)	76 (11)	179 (33)	111 (52)	29 (3)	155 (34)	2.30 (0.14)	80 (11)	138 (42)	30.0 (8.49)
Sub-basins	Cabot	4	72 (15)	86 (27)	78 (12)	166 (37)	168 (48)	31 (7)	313 (226)	1.57 (0.39)	94 (26)	155 (7)	4.13 (8.59)
Sub-basins	Flowerpot	7	75 (17)	51 (24)	59 (21)	119 (40)	104 (32)	22 (5)	156 (67)	1.44 (0.53)	87 (19)	140 (39)	0.66 (o.59)
Sub-basins	French River	3	79 (5)	66 (27)	71 (10)	163 (44)	169 (81)	25 (3)	143 (50)	3.13 (2.63)	97 (23)	157 (15)	19.07 (21.09)
Sub-basins	Parry Sound	1	200	61	42	204	210	35	530	1.70	81	116	1.00
	North Channel	53	151 (232)	39 (30)	42 (26)	105 (65)	116 (66)	22 (11)	125 (110)	1.46 (0.90)	66 (30)	93 (43)	1.83 (2.93)

TABLE 3.2-3

HEAVY METALS IN SURFICIAL SEDIMENTS OF LAKE HURON

Area	Sample Size	Zinc Min. Max.	Zinc Mean	Zinc Std. Dev.	Cadmium[a] Min. Max.	Cadmium[a] Mean	Cadmium[a] Std. Dev.	Lead[a] Min. Max.	Lead[a] Mean	Lead[a] Std. Dev.	Mercury[a] Min. Max.	Mercury[a] Mean	Mercury[a] Std. Dev.
		CONCENTRATION IN mg/kg											
Lake Huron	8	12.0	17.75	4.46	<1.9			9.4	16.55	6.3	<0.01		
A & B		25			2.9			29.0			<0.01		
Lake Huron	6	3.93	9.02	4.5	<2.0			1.3	15.5	11.0	0.006		
C		16.0			12.0			28.5			0.011		
Goderich	3	15.7	29.7	16.3	<2.0			33.1	49.9	16.1	0.019	0.059	0.035
Harbour		47.6			2.96			65.1			0.082		
Georgian Bay	12	7.5	65.1	35.1	<2.0			6.04	28.2	12.8	0.005		
D		115			2.9			47			0.064		
Georgian Bay	6	4.99	54.6	31.9	<1.0			<6.0			<0.01		
E		98.1			2.97			46.0			0.045		
Tobermory	3	81.6	90.5	8.7	2.85	2.91	0.06	60.7	75.6	24.6	0.042	0.051	0.008
Harbour		99.0			2.97			104.0			0.056		
Owen Sound	6	57.2	103.7	47.7	<2.0			26.4	75.6	53.1	0.026	0.166	0.143
Harbour		187.0			3.95			174.0			0.435		
Collingwood	3	99.1	116.4	15.1	3.92	4.19	0.27	85.8	162.3	98.9	0.084	0.146	0.06
Harbour		127.0			4.46			274.0			0.189		
Penetang-	8	89.0	130.5	42.6	<1.9			30.6	57.2	24.2	0.052	0.18	0.16
Midland		228.0			2.84			104.0			0.52		
Parry Sound	20	25	107.9	73.7	0.5			9	41.6	35.7	0.02	0.12	0.14
Harbour		290			3.98			160			0.534		
North Channel	19	17.8	95.29	71.42	<2.0			2.5	31.31	24.94	<0.01		
F		233.0			3.95			99.2			0.149		
Spanish	19	17.5	83.8	49.25	0.50	2.53	1.14	1.8	26.38	18.18	0.01	0.055	0.034
Harbour		213.0			3.98			82.0			0.127		
Serpent	20	44	155.9	52.3	<1.0			11	52.2	21.99	0.04	0.077	0.040
Harbour		226			2.0			83			0.12		
DeTour	1	5.4			<0.4			<1			<0.1		
Cheboygan	5	5.6	40.7	55.8	<0.4			<1	4.7	3.7	<0.1		
		140						10					
Presque Isle	1	34			<0.4			19			<0.1		
Alpena	6	24	31.0	7.3	<0.4			8	15.0	8.0	<0.1		
		44						30					
Harrisville	1	26			<0.4			4			<0.1		
Tawas City	6	12	19.6	5.5	<0.4			5	10.0	4.3	<0.1		
		26						16					
Harbor Beach	4	44	126.0	57.2	<0.4			12	26.5	10.5	<0.1		
		170						36					
Lexington	1	70			<0.4			13			<0.1		

Area	Sample Size	Copper[a] Min. Max.	Copper[a] Mean	Copper[a] Std. Dev.	Chromium[a] Min. Max.	Chromium[a] Mean	Chromium[a] Std. Dev.	Nickel[a] Min. Max.	Nickel[a] Mean	Nickel[a] Std. Dev.	Iron % Min. Max.	Iron % Mean	Iron % Std. Dev.
		CONCENTRATION IN mg/kg											
Lake Huron	8	2.9	10.2	7.6	5.5	12.5	4.6	3.0	11.9	4.9	0.4	0.71	0.25
A & B		25			20.0			19.0			1.1		
Lake Huron	6	<5.0			4.5	11.7	3.9	<4.5			0.4	0.56	0.27
C		7.5			16.5			21.0			1.1		
Goderich	3	12.8	18.0	6.9	15.2	20.9	6.7	10.8	16.67	6.34	0.55	0.92	0.40
Harbour		25.9			28.3			23.4			1.35		
Georgian Bay	12	<5.0	25.1	16.7	<7.0	25.5	16.4	11.8	36.7	17.9	0.40	2.28	1.36
D		52.0			55			58.0			4.0		
Georgian Bay	6	<5.0			<5.0			<5.0			0.73	1.75	0.58
E		32.3			35.6			78.0			2.4		
Tobermory	3	28.2	32.4	4.8	39.9	43.1	2.9	35.4	42.4	6.4	1.23	1.4	0.17
Harbour		37.7			45.7			47.9			1.56		
Owen Sound	6	20.0	38.6	14.7	14.0	17	4.2	27.0	31.4	6.9	1.18	1.5	0.49
Harbour		62.7			20.0			45.0			2.5		
Collingwood	3	37.2	44.7	6.85	23.8	24.7	1.29	28.3	31.3	2.7	1.08	1.14	0.07
Harbour		50.6			26.3			33.3			1.21		
Penetahg-	8	15.3	28.5	10.9	28.7	65.4	40.7	19.1	36.7	22.4	1.3	2.47	0.62
Midland		43.9			156.0			88.0			3.28		
Parry Sound	20	6.0	24.5	9.9	4.0	19.9	13.0	4.0	18.21	9.48	0.3	2.33	1.50
Harbour		42.0			53.5			32.0			6.7		
North Channel	19	<5.0			7.92	37.08	21.92	19.8	109.6	142.8	0.57	2.06	1.069
F		489.0			68.9			562			4.85		
Spanish	19	-		-	10	35.11	15.06		-	-	0.84	1.46	0.45
Harbour					62						2.42		
Serpent	20	14.0	40.45	15.34	13	29.95	9.15	20	103.5	95.84	0.89	1.88	0.51
Harbour		68.0			46			335			2.88		
DeTour	1	1.2			<0.2			2			0.26		
Cheboygan	5	1.0	4.60	3.99	2.0	6.72	6.48	<1	4.7	4.4	0.20	0.392	0.279
		16.0			18.0			12			0.86		
Presque Isle	1	11.0			7.8			20			0.48		
Alpena	6	3.8	6.53	3.24	3.0	5.26	1.66	6	10.0	3.2	0.32	0.460	0.128
		12.0			7.2			15			0.60		
Harrisville	1	1.8			2.8			5			0.62		
Tawas City	6	3.0	6.86	3.82	0.6	7.50	5.11	7	13.0	5.6	0.22	0.533	0.248
		12.0			14.0			20			0.80		
Harbor Beach	4	14.0	20.00	4.30	11.0	14.20	3.50	24	30.5	5.7	1.70	3.400	2.970
		24.0			19.0			38			7.80		
Lexington	1	4.6			3.4			10			0.52		

a. If mean and Std. Dev. are not shown, less than values were found for more than 15% of the samples.

TABLE 3.2-4

Mean Levels of Metals in Recent (Surface) and Pre-colonial (deeper) Sediment in Lake Huron

METAL	CONCENTRATION IN mg/kg	
	Recent	Pre-Colonial
Hg	0.210	0.150
Pb	129	39
Zn	197	94
Cd	2	1
Cu	58	38

a. Information from Reference (25).

TABLE 3.2-5

ESTIMATED LOADINGS OF ELEMENTS TO THE SEDIMENTS OF LAKE HURON[a]

ELEMENT	LOADING IN TONNES PER YEAR[b]		
	Anthropogenic[c]	Natural	Total
Hg	0.34	0.42	0.76
Pb	400	120	520
Zn	520	275	795
Cd	3	5	8
Cu	125	110	235
Organic C	33,900	126,700	160,600
N	5,180	16,200	21,380
P	1,460	3,290	4,750

a. Information from Reference (25).

b. Values calculated based on the results of three cores.

c. Anthropogenic refers to that fraction derived from man's activities as distinct from natural (background) sources.

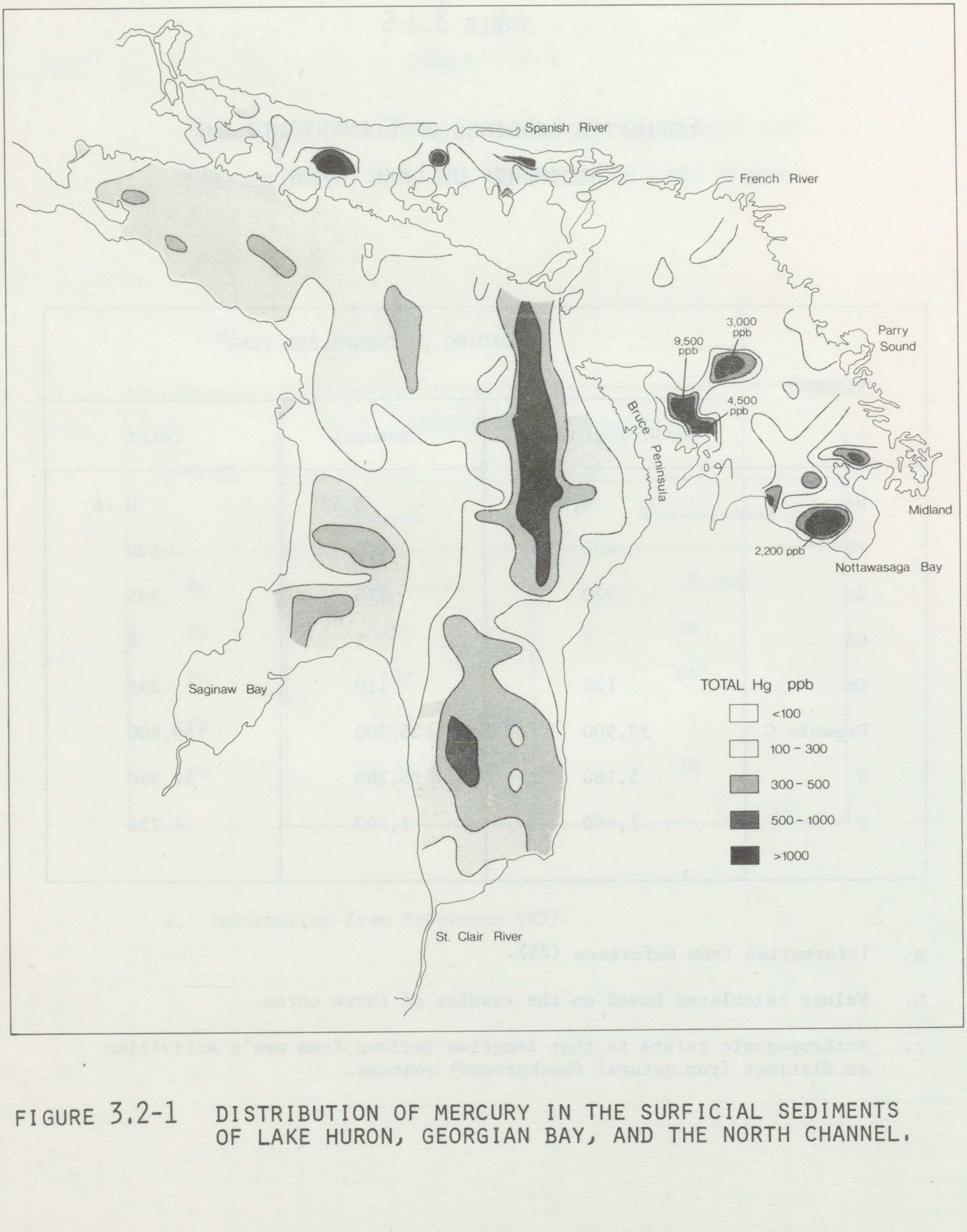


FIGURE 3.2-1 DISTRIBUTION OF MERCURY IN THE SURFICIAL SEDIMENTS OF LAKE HURON, GEORGIAN BAY, AND THE NORTH CHANNEL.

TABLE 3.2-6
LEAD IN GREAT LAKES SEDIMENTS - LAKE HURON
(Ref. 28)

LAKE HURON	N	$\bar{X}$ PPM	SD PPM	LOADINGS SED TONNES PER YR, X10^6	TONNES PB PER YEAR
Total Lake	177	49	34	-	-
Non Depositional Zone	97	35	28	-	-
Total Basin	80	66	35	-	690
Mackinac	11	67	41	-	-
Manitoulin	42	70	41	-	-
Alpena	2	59	7	-	-
Saginaw	4	87	19	-	-
Goderich	16	58	12	-	-
Port Huron	5	38	27	-	-

Acres Report

Atmospheric Loading

Model 690 tonnes/year

Precip. Chem. 460 tonnes/year

TABLE 3.2-7

LEAD IN GREAT LAKES SEDIMENTS - GEORGIAN BAY

(Ref. 28)

GEORGIAN BAY	N	$\bar{X}$ PPM	SD PPM
Total Lake	116	43	29
Non Depositional Zone	76	34	23
Total Basins	40	67	27
Nottawasaga	14	69	26
Owen Sound	6	57	31
Lion's	2	100	14
Cabot	4	86	27
Flowerpot	7	51	24
French River	3	66	27
Parry Sound	1	61	-
North Channel	55	39	30

Acres Report

Atmospheric Loading

Model	270 tonnes/year
Precip. Chem.	320 tonnes/year

TABLE 3.2-8

SAGINAW BAY SEDIMENT CHEMISTRY

PARAMETER (mg/kg)	CONCENTRATIONS IN mg/kg 1970 Min.	1970 Max.	1970 Mean	1973 Mean	1974 Min.	1974 Max.	1974 Mean	1975 Min.	1975 Max.	1975 Mean	EPA DREDGING GUIDELINES[b]
Cu		a		32.0	1.0	2.8	1.66	0.2	60.	23.	25-50
Cd		a		1.4			<0.4	<0.4	2.0	1.4	>6[c]
Zn		a		106	3.4	12	8.26	6.0	310	101.5	90-200
Fe	5400	9400	7140	6462	1600	7800	4600	1600	18000	9050	17,000-25,000
Mn		a		197	2.0	100	63.3	19.0	600	244	300-500
Cr		a		37.9	2.2	7.8	4.26	2.0	40.0	19.0	25-75
Pb		a		a			<1.0	<1.0	96.0	45.0	40-60
Hg			<0.2	a			<0.1	<0.02	0.16	0.12	>1.0[c]
TKN		a		a	38.0	240	110	80.0	2600	1150	1,000-2,000
Total P	280	540	340	2.0	9.0	38.0	20.3	21.0	180	75.5	420-650
COD	33000	110000	63500	a	1500	5200	2766	1300	110000	44775	40,000-80,000

a. Not analyzed.

b. Values given are for "moderately polluted" dredge spoil. "Heavily polluted" spoil is in excess of these values. See Appendix C.

c. Heavily polluted.

TABLE 3.2-9

LAKE HURON HARBOR SEDIMENTS - METAL ANALYSES

DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	CONCENTRATION - ppm dry weight MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	INFORMATION SOURCE
1974	Caseville Harbor	3	<.2	<10	12-78	90-130	<2-1	3.6-4.3	<3-7	<3	99
1975	Cheboygan Harbor	3	<.1	<10-56	13-89	<8-12	<2	<2	3-10	3-30	99
1974	Harbor Beach	5	<.2-<.3	<15-<25	94-120	180-280	2-8	7.1-8.8	37-51	16-36	99
1974	Sebewaing Harbor	7	<.1-<.3	<10-<15	16-130	90-240	<2-4	3.9-7.5	5-260	<3-10	99
1974	Saginaw Bay	9	<.3-<.5	<20-50	60-550	120-700	.2-.8	<.6-17	52-110	<3-62	99
1974	Saginaw River	8	<.2-.3	<10-60	70-250	50-430	2-7	3.8-8.7	26-470	11-82	99
1974	Port Sanilac	9	<.2-<.3	<10	20-88	70-230	1-6	2.3-12	4-30	<3-13	99
1974	Port Austin	3	<.2 <.3	<10-<15	33-115	90-170	3-4	4.2-7.8	7-54	3-22	99

TABLE 3.2-10

CALCITE HARBOR SEDIMENT CHEMISTRY
(Ref. 99)

PARAMETER (mg/kg)	1975 Min.	1975 Max.	1975 Mean	EPA DREDGING GUIDELINES[a]
Cu	0.6	6	4	25-50
Cd	0.2	0.2	0.2	>6[b]
Zn	9.4	26	19.4	90-200
Cr	3.4	26	16	25-75
Pb	4.0	12	8.8	40-60
Hg	.01	.07	.05	>1.0[b]
As	0.4	1.8	0.9	1,000-2,000
Ni	2	7	5.5	420-650
Se	0.1	0.4	0.2	40,000-80,000

[a]Values given are for "moderately polluted" dredge spoil. "Heavily polluted" spoil is in excess of these values.

[b]Heavily polluted.

NOTE: Calcite Harbor is located near Rogers City, Michigan

TABLE 3.2-11

ORGANIC CONTAMINANTS QUANTIFIED IN LAKE HURON BASIN SEDIMENTS

DATE	SAMPLE SITES	CONTAMINANTS AND QUANTITIES (μg/kg)	SOURCE
1974	Open lake and nearshore areas 18 sites	PCBs: Trace - 20 Dieldrin: N. D. - trace p,p-DDE: N. D. - 10 p,p-TDE: N. D. - 9 p,p-DDT: N. D. - 12 o,p-DDT: N. D. - 1 Σ DDT: N. D. - 22	12
1974-75	Saginaw Bay	Pesticides - PCBs: below detection limit Dibutyl phthalate - 290 μg/kg at Saginaw River mouth Dibutyl phthalate - <200 μg/kg at outer bay	96
1976	Saginaw Bay-River	PCBs - <0.1 - 22.9 mg/kg (vicinity of Saginaw sewage treatment plant)	100
		PCBs - 11.8 mg/kg (downstream of Bay City STP)	100
1974-75	St. Mary's River	Phenols - 13 mg/kg 5 km from Algoma Steel	96
1974-75	Nearshore areas	PCB, DDE, Dieldrin, DDD, p,p-DDT, o,p-DDT (See Table 3.2-12)	96
1974	1/4 mile upstream from Michigan Chemical Corp.	PBB <100	165
	St. Louis Reservoir (downstream from Michigan Chemical Corp.	PBB - 4800	
	29 miles from reservoir	PBB - 100	
1977	1/4 mile upstream from Michigan Chemical Corp.	PBB - 350	165
	St. Louis Reservoir	PBB - 7100	
	29 miles from reservoir	PBB - 150	

TABLE 3.2-12
1974-75
CONCENTRATIONS OF PCB'S AND PESTICIDES IN THE NEARSHORE SURFICIAL SEDIMENTS OF LAKE HURON

Area	Sample Size[d]	CONCENTRATION IN µg/kg					
		PCB	DDE	Dieldrin	DDD	pp DDT	op DDT
Lake Huron A & B	8	65 (2)	a	a	a	a	a
Lake Huron C	6	a	a	a	a	a	a
Georgian Bay D	12	46.6 (5)	2.5 (4)	1.6 (3)	2.8 (6)	1.5 (6)	a
Georgian Bay E	6	40 (1)	b	a	a	a	a
Tobermory Harbour	1	40	4	a	a	2	2
Owen Sound Harbour	6	267.5 (4)	13.6	4.5 (2)	14.3	4.2	a
Collingwood Harbour	3	853	8.3	a	14	5	c
Penetang-Midland	8	32 (4)	2.2 (2)	1.1 (4)	5 (2)	b	a
Parry Sound Harbour	19	a	a	a	a	a	a
North Channel F	19	a	3.5 (6)	a	4.3 (5)	6.7 (4)	7 (2)
Spanish Harbour	18	56.8 (16)	1.4 (16)	a	1.9 (16)	1.8 (16)	a
Serpent Harbour	16	a	1.3	a	a	a	a

a. Non-detectable.
b. Trace.
c. Not Analyzed.
d. Parentheses denote the number of samples above detection limit.

3.3 DATA ON AIR QUALITY AND PRECIPITATION

Atmospheric loadings to Lake Huron were calculated by Acres Consulting Services Ltd. and Applied Earth Science Consultants Inc. (101), and reported in the ULRG report (96) (Table 3.3-1). Twenty-two U.S. source regions and eleven Canadian source regions were considered to contribute to the loadings to Lake Huron, and the estimated contributions from each source are outlined in Table 3.3-2 (96). The Reference Group did not calculate the relative significance of atmospheric sources within material balances for substances such as mercury or PCBs because the "input sources sampled were below the detection limit for these materials."

Thirteen samples of rain over Lake Huron and Georgian Bay (46), indicated PCB and pesticide concentrations in nanogram per liter quantities, which are shown in Table 3.3-3.

Murphy in 1978, reported an average of 19 ng/l of PCBs in rain over Saginaw Bay, of which 70% was "dissolved" and 30% was "filterable or particulate". The calculated input of PCBs in $kg/km^2/yr$ was 0.014 (102).

Two PLUARG studies (170, 172) determined the levels of several pesticides, heavy metals and PCBs in rainwater collected in the Au Sable River Basin. The results are shown in Tables 1.3-3 to 1.3-5, under the designation of AG-3. The tables are found within the chapter on Lake Erie.

Table 3.3-4 shows the results of analyses for PAHs in air from Sudbury, Ontario (167).

TABLE 3.3-1

PERCENT OF LOADINGS TO LAKE HURON BY AIR POLLUTION SOURCE REGION[a]

Air Pollution Source Region[b]	Percent of Total Atmospheric Loading		
	Sulphate	Phosphorus	Trace Metals[c]
Saginaw	9.4	5.0	9.4
Detroit	7.2	9.0	11.7
Port Huron	3.2	1.1	1.3
Lower Michigan	1.0	1.2	2.1
Northern Michigan	0.7	2.7	3.3
St. Louis	3.9	4.5	5.2
Chicago	4.1	13.2	7.8
Central Illinois	2.2	2.5	2.6
Green Bay	1.1	3.1	2.0
Milwaukee	1.2	3.2	2.1
Wisconsin	0.3	2.2	0.9
Duluth	0.2	2.2	0.8
Minneapolis	0.6	1.5	1.3
Toledo	3.0	5.5	7.4
Cleveland	4.0	5.8	7.2
Cincinnati	5.3	9.2	10.5
Ohio	2.8	5.0	7.6
Pittsburgh	5.4	2.4	5.2
Pennsylvania	1.5	2.1	3.8
Rochester	0.2	0.4	0.4
Buffalo	0.2	0.5	0.4
S.W. New York	0.2	0.3	0.5
Montreal	0.2	3.2	0.6
Toronto	2.0	3.7	1.0
Sarnia	3.2	0.3	0.3
Sudbury	32.4	0.5	0.2
Thunder Bay	0.1	0.7	0.3
Nanticoke	0.3	0.1	0.1
Noranda	2.3	0.5	0.2
Sault Ste. Marie	0.2	1.4	1.6
Northern Ontario	0.9	0.1	0.4
Southern Ontario	0.2	2.2	1.5
Manitoba	0.5	4.7	0.3

a. From Reference (101).

b. United States Environmental Protection Agency and Ontario Ministry of the Environment air pollution source regions.

c. Cd, Cu, Fe, Ni, Pb

TABLE 3.3-2

ATMOSPHERIC LOADINGS TO LAKE HURON

Parameter	Loadings, In Tonnes Per Year[a]					
	Main Lake Huron			Georgian Bay	North Channel	Whole Lake Total
	North	South	Total			
Nitrogen ($NO_3 + NH_3$ as N)	22,000	12,000	34,000	14,200	3,780	52,000
Total Phosphorus[b]	255	195	450	134	36	620
Total Dissolved Solids[c]	42,000	30,000	72,000	30,000	7,980	110,000
Chloride	20,000	13,000	33,000	12,700	3,360	49,000
Reactive Silicate (as SiO_2)	4,900	2,600	7,500	1,340	355	9,200
Calcium	30,000	240,000	270,000	7,900	2,100	280,000
Sodium	19,000	23,000	42,000	2,370	630	45,000
Magnesium	4,100	2,600	6,700	1,190	315	8,210
Potassium	21,000	9,000	30,000	1,580	420	32,000
Iron	1,300	900	2,200	1,900	504	4,600
Lead	290	170	460	253	67	780
Copper	220	120	340	332	88	760
Nickel	36	44	80	103	27	210
Cadmium	42	17	59	16	4	79
Particulate Solids	90,000	140,000	230,000	94,800	25,200	350,000

a. All parameters were determined from actual measurements except for particulate solids values which were calculated from mathematical model results (101).

b. Corrected for contamination and further modified.

c. Calculated from conductivity measurements by multiplying by 0.65.

TABLE 3.3-3

ANALYSES OF 13 SAMPLES OF RAIN FROM

LAKE HURON - GEORGIAN BAY

(Ref. 46)

Parameter	CONCENTRATIONS (ng/ℓ)
Total PCB	11
Lindane	6.0
∝BHC	13.3
ΣDDT-Residues	2.7
∝Endosulfan	0.1
βEndosulfan	2.1
Dieldrin	1.0
Methoxychlor	13.1
HCB	0.0

TABLE 3.3-4

COMPARATIVE SEASONAL CONCENTRATION LEVELS OF PAH'S IN AIR OF ONTARIO CITIES
APRIL 1975-MARCH 1976

LOCATION: SUDBURY; SITE NO. 77016

(Ref. 167)

	April-June 1975		July-Sept. 1975		Oct.-Dec. 1975		Jan.-March 1976	
	ng/1000 m^3 Air	μg/g* p.m.	ng/1000 m^3 Air	μg/g p.m.	ng/1000 m^3 Air	μg/g p.m.	ng/1000 m^3 Air	μg/g p.m.
Benzo(a)pyrene	175	5.4	111	2.6	342	15.3	444	19.0
Benzo(e)pyrene	23	0.7	45	1.1	255	11.4	317	13.6
Benzo(b)fluoranthene	255	7.8	173	4.1	417	18.7	650	27.8
Benzo(k)fluoranthene	57	1.7	74	1.8	197	8.8	271	11.6
Perylene	17	0.5	17	0.4	41	1.8	50	2.1
Dibenz(def,mno)chrysene	8	0.2	9	0.2	37	1.7	32	1.4
Benzo(ghi)perylene	779	23.9	1104	26.3	2321	104.0	3009	128.7
Naptho(1,2,3,4,def)chrysene	510	15.6	73	1.7	99	4.4	230	9.8
Benzo(rst)pentaphene	40	1.2	10	0.2	17	0.8	36	1.5
Dibenzo(b,def)chrysene	149	4.6	47	1.1	54	2.4	130	5.6

*μg/g of particulate matter

3.4 DATA ON MUNICIPAL AND INDUSTRIAL DISCHARGES AND SLUDGES

Table 3.4-1 shows the results of a 1973 survey by U.S. EPA Region V (103) to determine the concentrations of organic contaminants in Lake Huron Basin municipal influents, effluents and sludges. Of the compounds detected, phthalate esters and the Aroclor compounds are found in the highest concentrations.

The Upper Lakes Reference Group in its Lake Huron Report (96), identified the significant industrial and municipal sources to the Lake Huron Basin. For example, the significant sources in Saginaw Bay are identified in pages 217-218 of the ULRG report. Also, there are considerable discussions within the report on the discharges from Algoma Steel to the St. Mary's River. For example, during 1974, the Reference Group estimated the quantities of discharges from Algoma Steel to be: 200 kg/d phenols; 11,000 kg/d ammonia; 2,280 kg/d cyanide. High levels of zinc and iron were also observed. The effects of these discharges are discussed in detail in pages 275-281 of the Reference Group's report.

TABLE 3.4-1

1973 SURVEY OF ORGANIC CONTAMINANTS IN LAKE HURON BASIN MUNICIPAL INFLUENTS, EFFLUENTS AND SLUDGES

COMPOUNDS SOUGHT [(a)]

Aroclor 1221, 1232, 1242, 1258, 1254, 1260, 1262, 1268	Methoxychlor
o,p-DDD	Di-N-butyl phthalate
p,p-DDD	Di-2-ethyl phthalate
o,p-DDE	Chlordane
p,p-DDE	Lindane
o,p-DDT	Heptachlor
p,p-DDT	Aldrin
Heptachlor epoxide	Dieldrin
	Endrin

Detection limits for phthalates were 0.05 μg/L (influent and effluent) and 0.05 mg/kg dry sludge. All other detection limits were 0.001 μg/L and 0.001 mg/kg for influents-effluents and sludges respectively.

MUNICIPAL PLANT	COMPOUNDS ABOVE QUANTIFICATION LEVELS AND CONCENTRATIONS	
Bay City, MI	Aroclor 1254:	Influent, 1.6 ppb Effluent, .91 ppb Sludge, 8-16 ppm
	p,p-DDD:	Sludge, .01-.04 ppm
	p,p-DDE:	Sludge, .1-.3 ppm
	Di-N-butyl phthalate:	Influent, 6 ppb Sludge, 110-190 ppm
	Di-2-ethyl phthalate:	Sludge, 32-210 ppm
	Chlordane:	Influent, 0.05 ppb
Flint, MI	Aroclor 1242:	Sludge, 6-7 ppm
	Aroclor 1254:	Influent, 2.9 ppb Effluent, 0.6-1.1 ppb Sludge, 4-5 ppm
	Lindane:	Influent, 0.03 ppb Effluent, 0.007-0.018 ppb
	Heptachlor:	Effluent, <.001-.007 ppb

TABLE 3.4-1 CONT'D

MUNICIPAL PLANT	COMPOUNDS ABOVE QUANTIFICATION LEVELS AND CONCENTRATIONS		
Flint, MI (continued)	Aldrin:	Influent,	0.28 ppb
		Effluent,	0.04-0.06 ppb
		Sludge,	0.02-0.03 ppm
	Heptachlor epoxide:	Sludge,	<.001-0.029 ppm
	Dieldrin:	Influent,	0.03 ppb
		Effluent,	<.001-.007 ppb
		Sludge,	0.009-0.056 ppm
	Endrin:	Influent,	0.03 ppb
		Effluent,	<.001-0.017 ppb
	p,p-DDT:	Sludge,	<.001-.025 ppm
	p,p-DDD:	Sludge,	.001-.014 ppm
	o,p-DDE:	Influent,	.02 ppb
		Sludge,	<.001-.045 ppm
	p,p-DDE:	Effluent,	<.001-.21 ppb
		Sludge,	0.012-.065 ppm
	Di-N-butyl phthalate:	Influent,	35 ppb
		Effluent,	<.05 ppb
		Sludge,	<.05-11 ppm
	Di-2-ethyl phthalate:	Influent,	23 ppb
		Effluent,	<.05 ppb
		Sludge,	21-110 ppm
Owosso, MI	Aroclor 1254:	Influent,	1.1 ppb
		Effluent,	1.3 ppb
		Sludge,	7-12 ppm
	Lindane:	Influent,	0.01 ppb
		Effluent,	0.016 ppb
	Heptachlor:	Effluent,	0.16 ppb
	Aldrin:	Influent,	0.26 ppb
		Effluent,	0.22 ppb
	Dieldrin:	Sludge,	0.25-.38 ppm
	o,p-DDT:	Sludge,	<.001-0.008 ppm
	p,p-DDD:	Sludge,	0.003-.21 ppm
	o,p-DDE:	Sludge,	<.001-.11 ppm
	p,p-DDE:	Influent,	0.35 ppb
		Effluent,	0.31 ppb
		Sludge,	<.001-1.4 ppm
	Di-N-butyl phthalate:	Influent,	70 ppb
		Effluent,	1100 ppb
		Sludge,	230-300 ppm

TABLE 3.4-1 CONT'D

MUNICIPAL PLANT	COMPOUNDS ABOVE QUANTIFICATION LEVELS AND CONCENTRATIONS	
Owosso, MI (continued)	Di-2-ethyl phthalate:	Sludge, 480-620 ppm
	Chlordane:	Influent, 0.04 ppb Effluent, 0.12 ppb

a) Source: U.S. EPA - Region V

3.5 DATA ON BENTHOS AND PLANKTON

Glooschenko et al. (12) reported that PCBs were observed at quantifiable levels in seston at all but one station in Lake Huron during 1974. At the remaining 14 stations, PCB concentrations between 0.5 to 8.1 ppm were found. Dieldrin and p,p^{1} - DDE were found in trace amounts in seston at most stations, with dieldrin appearing more frequently. Seston masses were collected with a plankton net which was dragged 2 m from the bottom or 100 m deep, depending which was more shallow. No organophosphorus compounds were detected.

3.6 DATA ON FISH CONTAMINANTS

There are three major fish contaminant monitoring programs on Lake Huron. The Ontario Min. Envir. and Min. Nat. Res. in the Fish Contaminant Analysis Program, regularly sample fish from the North Channel, Georgian Bay and several nearshore areas (North of Southampton, Denny's Dam and Goderich). Filets of many species of fish are analyzed primarily for mercury and PCBs. Organic scans are also utilized. Within the State of Michigan waters, the U.S. Fish and Wildlife National Pesticide Program determines a variety of pesticides and mercury in fish from areas near Bayport and Alpena. Table 3.6-1 illustrates the information from the National Pesticide Program on Lake Huron fish during 1974 (104). Also the GLECS program, described under section 1.6 on Lake Erie fish data, samples fish from 6 regions of Lake Huron which are illustrated in Figure 3.6-1. Examples of information from the GLECS program are shown in Table 3.6-2 (105).

The results of the above programs plus several other investigations, were integrated in the ULRG report, within which there are extensive discussions on contaminants in fish tissue. Some of the tables from the ULRG report (96) are presented here. Table 3.6-3 shows the results of an effort to evaluate the concentrations of 42 trace elements in burbot and bloater chubs from Lake Huron. Tables 3.6-4 to 3.6-9 show the concentrations of commonly sought heavy metals and chlorinated organics in several species of Lake Huron fish. Previously unrecognized contaminants are also shown in Tables 3.6-8 to 3.6-9, including compounds such as octachlorostyrene, nonachlor and methylbenzothiophene. The Reference Group noted that: "the identification of such a wide range of organics was not anticipated in these fish". "Of greatest concern is the fact that many of these compounds are noted for their stable characteristics and long lives in aquatic systems. They can only be attributed to products of man and his activities." "It is apparent that Lake Huron is being contaminated with persistent toxic organic compounds from essentially unknown sources."

Table 3.6-10 outlines additional data on organic contaminants in Lake Huron fish tissue (106-108). Efforts to detect the lampricide TFM (106) and mirex (107), showed the absence of these compounds in Lake Huron fish tissue. Table 3.6-11 shows the PBB concentrations observed in the Pine River. The Pine River flows into the Tittabawassee River, which meets with the Shiawassee River which eventually enters the Saginaw Bay.

A PLUARG study (171) determined organochlorine and heavy metal residues in shiners from the Saugeen and Nottawasaga Rivers. The concentrations are shown in Tables 1.6-11, 1.6-13 and 1.6-14 (Lake Erie section) and in Tables 3.6-12 and 3.6-13.

TABLE 3.6-1

NATIONAL PESTICIDE PROGRAM ANALYSIS OF LAKE HURON FISH

Locality and Species	Average Length inches	Average Weight pounds	Lipids %	DDE (µg/g)	TDE (µg/g)	DDT (µg/g)	Total DDT (µg/g)	Est. PCB's (µg/g)	Dieldrin (µg/g)
Lake Huron									
Bay Port, Mich.									
Yellow Perch	9.6	0.38	4.3	0.3	0.08	0.23	0.24	2.2	
Yellow Perch (R)	9.54	0.42	5.4	0.9	0.14	0.19	0.42	3.9	0.06
Carp	18.1	2.96	12.0	0.36	0.08		0.44	2.4	
Carp (dup)	--	--	11.8	0.35	0.10		0.45	3.0	
Channel Catfish	17.14	1.98	13.4	0.28	0.34	0.04	0.66	4.7	0.08
Lake Huron									
Alpena, Mich.									
Yellow Perch (4)	11.18	0.73	5.5	0.36	0.14		0.50	0.65	0.06
Yellow Perch (R) (3)	10.5	0.56	5.7	0.22	0.06	0.11	0.39	0.94	0.04
Yellow Perch (dup) (3)	--	--	5.4	0.19	0.06	0.10	0.35	0.73	0.03
White Sucker (3)	17.66	2.17	5.3	0.07	0.05	0.03	0.15	0.46	
Lake Whitefish	17.32	1.8	10.0	0.22			0.22		

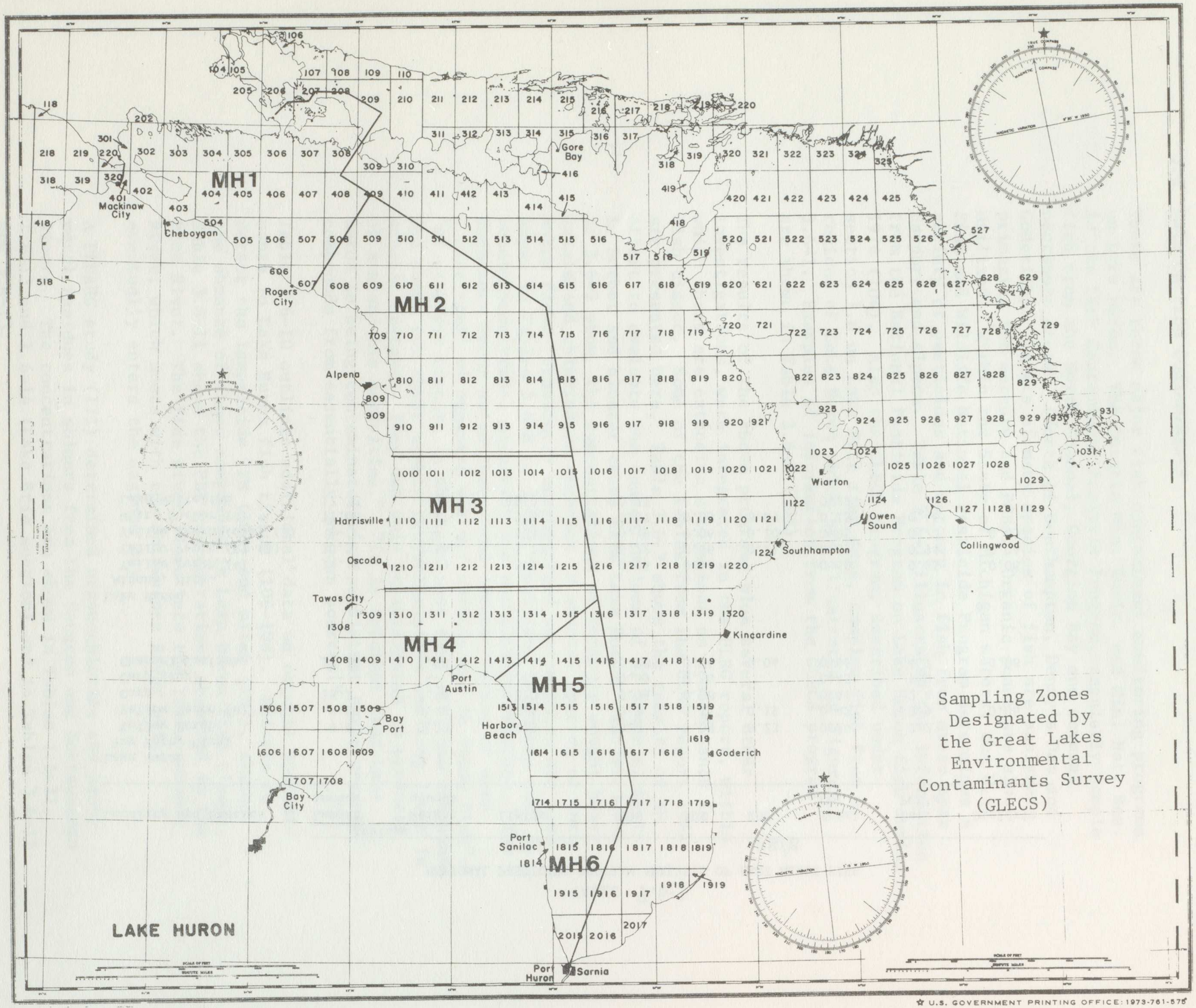

MH1
MH2
MH3
MH4
MH5
MH6
Mackinaw City
Cheboygan
Rogers City
Alpena
Harrisville
Oscoda
Tawas City
Port Austin
Bay Port
Harbor Beach
Bay City
Port Sanilac
Port Huron
Sarnia
Gore Bay
Wiarton
Owen Sound
Collingwood
Southhampton
Kincardine
Goderich
LAKE HURON
Sampling Zones
Designated by
the Great Lakes
Environmental
Contaminants Survey
(GLECS)
U.S. GOVERNMENT PRINTING OFFICE: 1973-761-575

FIGURE 3.6-1

TABLE 3.6-2

SUMMARY OF GLECS LAKE HURON FISH CONTAMINANT DATA PREPARED BY THE MICHIGAN DEPARTMENT OF AGRICULTURE

Date	Zone[a]	Species	Size	Number	Contaminant Level (ppm) DDT	PCB	Mercury	Dieldrin
1974	MH-1	Brown Trout	<3 lbs.	3	00.31	00.35	00.13	00.01
			3-5 lbs.	3	00.58	01.09	00.10	00.02
1974	MH-2	Brown Trout	<3 lbs.	3	00.21	00.26	00.06	00.02
1974	MH-3	Brown Trout	5-10 lbs.	3	00.79	01.93	00.20	00.05
1974	MH-4	Carp	<5 lbs.	5	00.25±0.10	01.06±0.54	00.07±0.04	00.00
			>5 lbs.	3	01.14	04.30	00.05	00.02
1974	MH-3	Chinook Salmon	2-3 lbs.	4	00.54	01.29	00.00	00.03
			3-5 lbs.	2	00.51	00.77	00.00	00.06
			5-10 lbs.	1	01.26	02.97	00.00	00.07
1974	MH-3	Salmon	3-5 lbs.	1	00.13	00.48	00.10	00.03
			5-10 lbs.	2	00.56	01.36	00.10	00.04
			>10 lbs.	3	01.52	03.54	00.34	00.06
1974	MH-4	Suckers	<16 in.	2	00.02	00.15	00.01	00.00
			>16 in.	2	00.12	00.61	00.06	00.00
1974	MH-1	Walleye	<13 in.	3	00.02	00.00	00.20	00.00
			>13 in.	9	00.04	00.00	00.16±0.05	00.00
1974	MH-1	Yellow Perch	<9 in.	16	00.00	00.00	00.17±0.05	00.00
			>9 in.	20	00.00±0.00	00.00	00.33±0.10	00.00
1974	MH-2	Yellow Perch	>9 in.	6	00.03±0.02	00.02±0.03	00.15±0.06	00.02
1974	MH-4	Yellow Perch	<9 in.	32	00.01±0.02	00.03±0.10	00.04±0.00	00.00
			>9 in.	14	00.06±0.04	00.23±0.20	00.17±0.00	00.00
1975	MH-2	Brown Trout	<3 lbs.	3	00.36	00.64	00.08	00.03
			3-5 lbs.	2	00.83	01.70	00.17	00.05

(continued)

TABLE 3.6-2 CONT'D

Date	Zone[(a)]	Species	Size	Number	Contaminant Level (ppm) DDT	PCB	Mercury	Dieldrin
1975	MH-2	Brown Trout	5-10 lbs.	1	00.53	01.14	00.15	00.03
1975	MH-4	Carp	<5 lbs.	3	00.11	00.93	00.07	00.00
			>5 lbs.	5	00.39±0.06	02.00±0.57	00.06±0.00	00.00±0.00
1975	MH-5	Carp	<5 lbs.	10	00.22±0.18	00.92±0.86	00.16±0.09	00.00±0.00
			>5 lbs.	2	00.72	02.75	00.08	00.02
1975	MH-1	Lake Trout	<3 lbs.	12	00.58±0.27	00.99±0.44	00.12±0.00	00.05±0.00
			3-5 lbs.	6	01.33±0.28	02.16±0.38	00.16±0.02	00.08±0.00
1975	MH-5	Lake Trout	5-10 lbs.	1	00.52	05.70	00.37	00.08
1975	MH-1	Smelt	NO CATEGORY	2	00.48	00.69	00.07	00.02
1975	MH-4	Smelt	NO CATEGORY	1	00.17	00.80	00.42	00.00
1975	MH-1	Suckers	<16 in.	4	00.36	00.66	00.07	00.03
			>16 in.	2	00.45	00.59	00.13	00.05
1975	MH-1	White Fish	<17 in.	3	00.21	00.23	00.05	00.05
			17-20 in.	3	00.14	00.20	00.07	00.02
			>20 in.	3	00.24	00.25	00.06	00.06
1975	MH-3	White Fish	<17 in.	1	00.20	00.23	00.00	00.06
			17-20 in.	4	00.24	00.43	00.00	00.06
			>20 in.	3	00.24	00.38	00.00	00.08

(a) See Figure 3.6-1 for zone designations

TABLE 3.6-3

TRACE ELEMENTS DETECTED BY SPARK SOURCE MASS SPECTROMETRY IN WHOLE-FISH SAMPLES OF BURBOT AND BLOATER CHUB FROM OPEN WATERS OF LAKE HURON OFF GODERICH, ONTARIO

ELEMENT	CONCENTRATION IN μg/g	
	BURBOT	BLOATER CHUB
Lead (Pb)	0.095	0.075
Neodymium (Nd)	a	a
Praseodymium (Pr)	a	0.020
Cerium (Ce)	a	a
Lanthanum (La)	0.025	0.060
Barium (Ba)	0.25	0.030
Cesium (Cs)	a	a
Iodine (I)	18	12
Tellurium (Te)	0.050	a
Tin (Sn)	0.82	0.35
Indium (In)	0.025	0.055
Cadmium (Cd)	a	0.170
Silver (Ag)	0.060	0.080
Rhodium (Rh)	a	a
Molybdenum (Mo)	0.030	a
Zirconium (Zr)	a	a
Strontium (Sr)	3.2	3.8
Rubidium (Rb)	2.4	2.2
Bromine (Br)	8.5	5.3
Selenium (Se)	0.19	0.28
Arsenic (As)	0.005	0.013
Germanium (Ge)	0.16	1.3
Gallium (Ga)	0.02	0.12
Zinc (Zn)	16	25
Copper (Cu)	a	a
Nickel (Ni)	a	a
Cobalt (Co)	0.24	1.0
Iron (Fe)	22	11
Manganese (Mn)	1.7	2.4
Chromium (Cr)	0.68	1.8
Vanadium (V)	0.075	0.26
Titanium (Ti)	0.13	0.16
Scandium (Sc)	0.075	0.44
Aluminum (Al)	a	a
Fluorine (F)	0.83	0.27
Calcium (Ca)	>54	>27
Potassium (K)	>13	>6
Chlorine (Cl)	>50	>20
Sulphur (S)	>22	>60
Phosphorus (P)	>26	>15
Magnesium (Mg)	>22	>9
Sodium (Na)	>25	>14

a. Not detected

TABLE 3.6-4

MEAN CONCENTRATIONS (MG/KG WET WEIGHT BASIS) OF SELECTED TRACE CONTAMINANTS IN FISH COLLECTED FROM NEARSHORE LAKE HURON WATERS, 1974 AND 1975

LOCATION		SPECIES	DDT	PCB	DIELDRIN	Hg	Cu	Zn	Pb	Cd
MICHIGAN										
Detection Limit			0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Hammond Bay		Brown Trout	0.57	1.13	0.02	0.13	0.74	3.46	0.11	0.03
		Perch	b	b	b	0.31	0.56	4.60	0.26	0.10
		Rainbow Trout	0.32	0.94	0.03	0.10	0.61	3.78	0.07	0.03
		Walleye	0.03	b	b	0.17	0.28	3.80	0.23	0.30
		Whitefish	0.26	b	0.05	0.04	0.64	3.59	0.71	b
Alpena	1974	Brown Trout	0.50	1.10	0.04	0.13	0.33	2.90	0.10	0.01
		Chinook	0.97	2.31	0.05	0.22				
		Perch	0.03	b	<0.01	0.15	0.37	4.69	0.18	0.03
		Whitefish	0.35	0.34	0.05	0.03				
	1975	Perch	0.04	0.13	b	0.26	0.29	8.12	0.77	0.04
Tawas City	1974	Whitefish	0.12	0.22	0.03	0.03				
	1975	Perch	0.07	0.20	b	0.27	0.27	7.64	0.38	0.03
Harbor Beach		Perch	0.13	0.30	b	0.34	0.31	7.70	0.40	0.03
Lexington		Perch	0.05	0.13	b	0.33	0.24	7.12	0.32	0.03
ONTARIO										
Detection Limit			0.001	0.001	0.001	0.01	0.01	0.01	0.5	0.2
Goderich		Perch	0.017	0.089	0.002	0.22	0.41	6.50	<0.5	<0.2
		Rainbow Trout	0.485	1.943	0.045	0.18	0.68	4.92	<0.5	<0.2
		White Sucker	0.261	0.606	0.034	0.14	0.75	6.57	<0.5	<0.2
Douglas Point		Rainbow Trout	0.549	2.179	0.035	0.16	0.75	4.85	<0.5	<0.2
		White Sucker	0.112	0.356	0.009	0.23	0.64	6.32	<0.5	<0.2
		Northern Pike	0.148	0.515	0.004	0.40	0.39	5.84	<0.5	<0.2
Owen Sound		Perch	0.037	0.189	0.003	0.29	0.59	7.53	<0.5	<0.2
		Rainbow Trout	0.338	1.073	0.036	0.19	0.65	6.42	<0.5	<0.2
		White Sucker	0.325	0.693	0.031	0.11	0.61	6.65	<0.5	<0.2
Thornbury		Perch	0.017	0.093	0.002	0.22	0.45	6.90	<0.5	<0.2
		Rainbow Trout	0.376	0.910	0.030	0.20	0.57	6.43	<0.5	<0.2
		White Sucker	0.323	0.562	0.023	0.10	0.62	7.70	<0.5	<0.2
Nottawasaga		Perch	0.040	0.183	0.003	0.32	0.64	4.30	<0.5	<0.2
		Rainbow Trout	0.415	1.207	0.034	0.18	0.53	5.09	<0.5	<0.2
		Walleye	0.351	0.827	0.010	0.57	0.37	4.30	<0.5	<0.2
		White Sucker	0.723	1.153	0.051	0.16	0.74	6.27	<0.5	<0.2
Penetang-Midland		Perch	0.024	0.115	0.002	0.27	0.60	7.15	<0.5	<0.2
		Walleye	0.114	0.258	0.004	0.46	0.46	4.43	<0.5	<0.2
		Rock Bass	0.011	0.074	0.002	0.17	0.55	7.43	<0.5	<0.2
Spanish River		Perch	0.007	0.046	<0.001	0.27	0.60	6.23	<0.5	<0.2
		White Sucker	0.037	0.131	0.003	0.06	0.57	6.70	<0.5	<0.2
		Northern Pike	0.024	0.114	<0.001	0.25	0.46	5.20	<0.5	<0.2
Serpent River		Perch	0.027	0.149	0.002	0.31	0.54	7.26	<0.5	<0.2
		White Sucker	0.043	0.125	0.004	0.04	0.66	5.78	<0.5	<0.2
		Northern Pike	0.085	0.266	0.001	0.40	0.49	6.45	<0.5	<0.2
Lake George		Perch	0.003	0.068	0.001	0.23	0.55	5.73	<0.5	<0.2
		White Sucker	0.073	0.194	0.004	0.13	0.64	5.55	<0.5	<0.2
		Northern Pike	0.024	0.096	b	0.02	0.41	4.99	<0.5	<0.2

b. Not detected.

TABLE 3.6-5

MEAN CONCENTRATIONS OF TRACE METALS AND ORGANIC CONTAMINANTS (μG/G) AND FAT (%) IN BURBOT (WHOLE FISH) FROM THE OPEN WATERS OF LAKE HURON[a,b]

Compound or element	Lonely Island		Goderich		Straits of Mackinac		Lake average (unweighted)
N[c]	15		52		50		
n[d]	10		10		10		
Fat	5	(0.52)	5	(0.15)	7	(0.35)	
Total PCB	0.81	(0.19)	0.77	(0.05)	2.35	(0.31)	1.31
Total DDT	1.04	(0.35)	0.53	(0.05)	1.77	(0.26)	1.11
op' DDT	0.08	(0.02)	0.04	(0.005)	0.10	(0.01)	0.07
op' DDE	0.02	(0.005)	0.03	(0.005)	0.01	(0.002)	0.02
pp' DDT	0.31	(0.07)	0.16	(0.02)	0.52	(0.08)	0.33
pp' DDE	0.52	(0.22)	0.22	(0.02)	1.00	(0.15)	0.58
pp' DDD	0.11	(0.03)	0.08	(0.01)	0.15	(0.02)	0.11
Dieldrin	0.07	(0.008)	0.08	(0.01)	0.12	(0.01)	0.09
Lindane			0.04	(0.01)	0.01	(0.006)	0.02
Chlordane			0.14	(0.01)	0.18	(0.02)	0.16
Methoxychlor			<0.05		<0.05		
Mercury	0.11	(0.008)	0.06	(0.003)	0.18	(0.008)	0.12
Arsenic			0.23	(0.01)	0.46	(0.02)	0.35
Cadmium			0.02	(0.001)	0.02	(0.001)	0.02
Chromium			0.07	(0.004)	0.12	(0.008)	0.10
Copper			0.75	(0.05)	0.80	(0.04)	0.78
Lead			0.07	(0.01)	0.04	(0.002)	0.05
Selenium			0.80	(0.02)	0.66	(0.007)	0.73
Zinc			11.8	(0.21)	12.7	(0.41)	12.2

a. The number in parentheses is the standard error of the mean.
b. No burbot were collected at Duck Island, Harbor Beach, and Alpena.
c. Number of individual fish.
d. Number of composites analyzed.

TABLE 3.6-6

MEAN CONCENTRATIONS OF TRACE METALS AND ORGANIC CONTAMINANTS (μG/G) AND FAT (%) IN BLOATER CHUBS (WHOLE FISH) FROM THE OPEN WATERS OF LAKE HURON[a,b]

Compound or element	Duck Island	Lonely Island	Goderich	Alpena	Straits of Mackinac	Lake average (unweighted)
N[c]	53	42	50	14	29	
n[d]	10	10	10	10	10	
Fat	21 (0.88)	9 (0.44)	20 (0.66)	21 (1.1)	22 (1.1)	
Total PCB	1.25 (0.22)	0.89 (0.10)	1.48 (0.12)	2.61 (0.21)	1.68 (0.26)	1.58
Total DDT	1.46 (0.06)	2.17 (0.21)	2.75 (0.53)	4.37 (0.45)	3.52 (0.51)	2.85
op' DDT	0.16 (0.02)	0.16 (0.01)	0.33 (0.07)	0.40 (0.04)	0.34 (0.04)	0.28
op' DDE	0.06 (0.007)	0.03 (0.004)	0.28 (0.04)	0.08 (0.01)	0.07 (0.01)	0.10
pp' DDT	0.42 (0.07)	0.76 (0.06)	0.86 (0.22)	1.60 (0.18)	1.18 (0.02)	0.96
pp' DDE	0.70 (0.07)	1.11 (0.12)	1.02 (0.17)	2.05 (0.25)	1.69 (0.26)	1.31
pp' DDD	0.12 (0.01)	0.11 (0.02)	0.26 (0.03)	0.24 (0.02)	0.24 (0.05)	0.19
Dieldrin	0.18 (0.01)	0.08 (0.008)	0.38 (0.04)	0.20 (0.02)	0.29 (0.04)	0.28
Lindane			0.03 (0.003)		0.04 (0.01)	0.04
Chlordane			0.49 (0.05)		0.30 (0.04)	0.40
Methoxychlor			<0.05		<0.05	
Mercury	0.05 (0.003)	0.17 (0.008)	0.08 (0.003)	0.10 (0.004)	0.11 (0.005)	0.10
Arsenic			1.72 (0.07)		2.26 (0.13)	1.99
Cadmium			0.02 (0.002)		0.04 (0.004)	0.03
Chromium			0.02 (0.002)		0.05 (0.005)	0.04
Copper			0.69 (0.03)		0.79 (0.03)	0.74
Lead			0.06 (0.003)		0.10 (0.01)	0.08
Selenium			0.63 (0.02)		0.56 (0.02)	0.60
Zinc			17.0 (0.74)		15.6 (0.74)	16.3

a. The number in parentheses is the standard error of the mean.
b. No bloater chubs were collected at Harbor Beach.
c. Number of individual fish.
d. Number of composites analyzed.

TABLE 3.6-7

MEAN CONCENTRATIONS OF TRACE METALS AND ORGANIC CONTAMINANTS (μG/G) AND FAT (%) IN SLIMY SCULPINS (WHOLE FISH) FROM THE OPEN WATERS OF LAKE HURON[a,b]

Compound or element	Duck Island		Lonely Island		Harbor Beach		Alpena		Straits of Mackinac		Lake average (unweighted)
N[c]	51		47		50		44		72		
n[d]	10		10		10		10		10		
Fat	6	(0.45)	5	(0.36)	6	(0.33)	6	(0.62)	8	(0.36)	6.2
Total PCB	0.52	(0.04)	0.71	(0.21)	0.77	(0.04)	0.55	(0.07)	0.81	(0.14)	0.67
Total DDT	0.60	(0.03)	0.76	(0.05)	0.65	(0.03)	0.65	(0.10)	0.66	(0.03)	0.66
op' DDT	0.10	(0.009)	0.06	(0.005)	0.08	(0.005)	0.07	(0.01)	0.09	(0.006)	0.08
op' DDE	0.03	(0.002)	0.01	(0.001)	0.03	(0.003)	0.04	(0.006)	0.03	(0.003)	0.03
pp' DDT	0.21	(0.01)	0.31	(0.03)	0.25	(0.02)	0.25	(0.04)	0.22	(0.02)	0.25
pp' DDE	0.20	(0.01)	0.34	(0.02)	0.21	(0.08)	0.22	(0.04)	0.24	(0.01)	0.24
pp' DDD	0.06	(0.004)	0.04	(0.004)	0.08	(0.004)	0.06	(0.007)	0.08	(0.004)	0.06
Dieldrin	0.14	(0.01)	0.07	(0.006)	0.11	(0.006)	0.14	(0.02)	0.14	(0.008)	0.12
Lindane									0.03	(0.006)	
Chlordane									0.17	(0.01)	
Methoxychlor									<0.05		
Mercury	0.06	(0.004)	0.12	(0.004)	0.08	(0.004)	0.08	(0.006)	0.07	(0.003)	0.08
Arsenic									0.38	(0.01)	
Cadmium											
Chromium											
Copper									2.92	(0.12)	
Lead											
Selenium									0.81	(0.01)	
Zinc									17.2	(0.66)	

a. The number in parentheses is the standard error of the mean.
b. No slimy sculpins were collected at Goderich.
c. Number of individual fish.
d. Number of composites analyzed.

TABLE 3.6-8

CONTAMINANTS MEASURED IN FISH FROM NEARSHORE LAKE HURON WATERS[a]

	Ontario	Michigan
Heptachlor-heptachlor epoxide	*	
Dieldrin	*	*
Aldrin	*	
Lindane	*	*
Endrin	*	
DDT	*	*
DDD	*	*
DDE	*	*
Chlordane	*	*
Methoxychlor		*
Polychlorinated biphenyl (PCB)	*	*
Polybrominated biphenyl		*
Hexachlorobutadiene		*
Hexachlorobenzene		*
Dibutylphthalate		*
Diethylhexylphthalate		*
Copper	*	*
Nickel	*	*
Lead	*	*
Zinc	*	*
Cadmium	*	*
Manganese	*	
Arsenic	*	*
Chromium	*	*
Selenium	*	
Mercury	*	*
Gross α	*	
Gross β	*	
Individual fish		*
Composite	*	*
Fillets	*	*

a. Information from Reference 96.

TABLE 3.6-9

ORGANIC COMPOUNDS (NONIONIC) DETECTED (+) AND NOT DETECTED (-) BY COMBINED GAS CHROMATOGRAPHY - MASS SPECTROMETRY IN WHOLE-FISH SAMPLES OF BURBOT FROM OPEN WATERS OF LAKE HURON

COMPOUND	ESTIMATED CONCENTRATION RANGE DETECTED (μg/g)	STRAITS OF MACKINAC	GODERICH
Biphenyl	0.01-0.1	−	+
Naphthalene and methyl naphthalenes	0.01-0.5	+	+
Phenanthrene and methyl phenanthrenes		+	+
Diethyl phthalate		+	+
Dibutyl phthalate	0.01-0.1	+	+
Di-2-ethyl hexylphthalate		+	+
Trichlorobenzene		+	+
Tetrachlorobenzene	0.01-0.5	−	+
Pentachlorobenzene		−	+
Hexachlorobenzene		+	+
Chlorobiphenyl (tri- through octachloro PCB's)		+	+
Octachlorostyrene	0.001-0.01	−	+
1,2,3,4,5,6-Hexachlorocyclohexane			
(alpha isomer)	<0.1	−	−
(gamma isomer)	<0.1	−	−
Heptachlor epoxide	0.1-1.0	+	−
Chlordane (cis- and trans-)	0.1-1.0	+	+
Nonachlor (cis- and trans-)	0.1-1.0	+	+
Oxychlordane	0.01-0.1	+	−
Dieldrin	<0.1	−	−
pp' DDT	1-10	+	+
op' DDE	0.1-1.0	+	−
pp' DDE	1-10	+	+
pp' DDD	0.1-1.0	+	+
pp' DDMu	<0.01	−	−
Toxaphene components ($C_{10}H_8Cl_{7,8}$,trans-)	0.1-1.0	+	−
Methylbenzothiophene	0.01-0.1	−	+

TABLE 3.6-10

ADDITIONAL DATA ON ORGANIC CONTAMINANTS IN
LAKE HURON BASIN FISH TISSUE

Date and Location	Species	Contaminant Identified or Sought and Concentration	Source
1973 - Hammond Bay	Chinook Salmon	TFM (none detected)	106
1977 - Saginaw River	?	Dichlorobenzene, trichlorobenzene tetrachlorobenzene, pentachlorobenzene, hexachlorobenzene, heptrachlorostyrene, octachlorostyrene, pentachloroanisole, pentachlorophenol, cis-chlordane, trans-chlordane, trans-nonachlor, cis-nonachlor, DDT, DDE	108
1976 - Georgian Bay Nottawasaga River	Rainbow Trout	Mirex (not detected)	107
1976 - Saugeen River	Rainbow Trout	PCB - 1.50 ppm (0.25-4.10 ppm)	107
1976 - Saugeen River	Chinook Salmon	PCB - 2.8 ppm (0.6-4.8 ppm)	107
1978 - Saginaw and Tittabawasse Rivers	?	PCB - 2.1 ppm PBB - 2.8 ppm TCDD - 0.01-.02 ppb	162

TABLE 3.6-11

PBB IN PINE RIVER FISH, 1974 AND 1976

		PBB concn. mg/kg[a]				
Year	Species	Alma Reservoir (Above Mich. Chemical Corp.)	St. Louis Reservoir(o)[b]	Bagley Road(6)[b]	Magrudder Road(12)[b]	Prairie Road(29)[b]
1974	Carp	ND	ND	0.87	0.19	0.26
			1.33	1.26	0.09	
			0.85			
	White Sucker	ND			0.67	
	Northern Pike	ND		0.54		
	Bullhead	ND		0.45	0.78	
1976	Carp	ND	0.75	0.40	0.22	0.06
					0.68	0.10
	Northern pike	ND	0.18		0.23	
	Largemouth bass	ND		0.74	0.19	ND
	Smallmouth bass					0.13
	Rockbass			0.70	0.50	0.32

(a) Wet weight, skinless fillets, composite samples.
(b) Distance below Michigan Chemical Corporation (miles)
(c) None detected

Table 3.6-12 HEAVY METAL RESIDUES FOUND IN OTHER MINNOWS COLLECTED 1977 (µg/g) (MEANS AND 95% CONFIDENCE LIMITS)

SITE LOCATION	Fish Species	Sample No.	Length T.L. (mm)	% Lipid	Hg	Cu	Zn	Pb	As
GEORGIAN BAY									
Nottawasaga River	emerald shiners	10	83±3	10±1	0.048±0.004	-*	-*	-*	-*
LAKE HURON									
Saugeen River	emerald shiners	10	81±3	6±1	0.084±0.03	-*	-*	-*	-*
Saugeen River	common shiners	10	54±2	5±1	0.094±0.008	-*	-*	-*	-*
LAKE ONTARIO									
Humber River	emerald shiners	10	58±2	7±0.4	0.066±0.003	1.35±0.4	39±8		0.18±0.06
Salmon River	golden shiners	10	70±2	4.02	0.023±0.003	-*	-*	-*	-*

*not analyzed for

Table 3.6-13

ORGANOCHLORINE CONTAMINANT RESIDUES FOUND IN OTHER MINNOWS COLLECTED, 1977 (ng/g) (MEANS AND 95% CONFIDENCE LIMITS)

SITE LOCATION	Fish Species	Sample No.	Length T.L. (mm)	% Lipid	PCB	ΣDDT	Mirex	HCB	χBHC	Lindane	βBHC	Heptachlor	Heptachlor Epoxide	Aldrin	Dieldrin	Endrin	Chlordane χ	Chlordane γ
GEORGIAN BAY																		
Nottawasaga R.	emerald shiner	10	83±3	10±1	241±72	160±9	ND	ND	7±1	1±1	ND	ND	3±0.4	ND	12±5	4±2	3±1	14±2
LAKE HURON																		
Saugeen R.	emerald shiner	10	81±3	6±1	188±23	100±18	ND	ND	2±1	2±2	ND	ND	1±1	ND	ND	ND	16±5	ND
Saugeen R.	common shiner	10	54±2	5±1	182±39	60±19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12±6	ND
LAKE ONTARIO																		
Humber River	emerald shiner	10	58±2	7±0.4	1090±79	289±26	13±1	14±2	50±11	6±2	ND	ND	2±0.3	ND	17±1	3±1	4±1	41±6
Salmon River	golden shiner	10	70±2	4±0.2	144±61	45±9	ND	ND	3±1	ND	ND	ND	ND	ND	ND	ND	2±2	12±3

ND = non detectable

3.7 DATA ON WILDLIFE

Table 3.7-1 illustrates the concentrations of PBB found in ducks from the Pine River. Table 3.7-2 shows the contaminant levels found in Lake Huron herring gull eggs (74). In 1977, investigators found that PCB residues increased from 1975 levels and there have not been any significant changes in the levels of other contaminants.

TABLE 3.7-1

PBB IN DUCKS COLLECTED FROM THE PINE RIVER WITHIN 2 MILES DOWNSTREAM FROM ST. LOUIS

Species	Year	Number in Sample	PPB in Breast Tissue (whole weight), mg/kg	
			With Skin	Skinless
Mallard	1974	3	-	0.25
	1976	3	2.00	0.24
	1977	-	-	-
Wood Duck	1974	3	-	0.29
	1976	4	2.70	0.17
	1977	4	0.23	0.08
Teal	1974	3	-	1.8
	1976	-	-	-
	1977	1	ND	ND

TABLE 3.7-2

ANALYSES FOR ORGANIC CONTAMINANTS IN LAKE HURON WILDLIFE

(mg/kg fresh weight)

DATE	SAMPLING SITE	NO. SAMPLES	SPECIES	PORTION ANALYZED	MIREX	DDE	DDD	DDT	DIEL-DRIN	HEPTA-CHLOR EPOXIDE	BHC	HCB	OXY-CHLOR-DANE	PCBs	PCBs AROCLOR 1260	PHOTO MIREX	SOURCE
1975	Double Island	10	Herring gulls	eggs	.55±.67	16±9	-	.05±.03	.4±.2	.09±.05	-	.3±.04	-	-	35±11		74
1977	Double Island	10	"	"	.55±.57	19±15	.26±.12	.09±.02	.5±.2	-	.05±.02	.21±.05	-	-	66±42	.22±.20	74
1975	Chanty Island	10	Herring gulls	eggs	.48±.56	12±4	.02±.03	.04±.03	.3±.2	.07±.03	-	.09±.03	-	-	30±13		74
1977	Chanty Island	10	"	"	.34±.22	13±5	.23±.08	.09±.05	.6±.3	-	.04±.03	.17±.08	-	-	53±14	.14±.08	74
1975-5	Lake Huron	40	Herring gulls	eggs	0.56 .06-6.92	13.8 5.4-41.9	0.10 TR-.38	0.08 .01-.32	0.41 .13-.87	0.12 .04-.26		0.14 .05-.42	-	51.5 15.4-118			73

4 LAKE SUPERIOR BASIN

As in the case of Lake Huron water quality data, extensive data on Lake Superior was compiled by the Upper Lakes Reference Group (ULRG) and subsequently reported to the International Joint Commission in July 1977 (109). Most of the data reported in this chapter was obtained from the ULRG report, as well as data submitted by various government agencies, and recent reports of several research investigators.

4.1 DATA ON WATER QUALITY

Heavy Metals

Since 1970, several lake-wide chemical monitoring cruises on Lake Superior have occurred, resulting in assessments of concentrations of major ions, nutrients, trace metals and organic contaminants. The concentrations of heavy metals determined during these cruises and during several nearshore studies are shown in Table 4.1-1. In 1970-71, Chan and Saitoh (4) determined the distributions of total mercury in the surface and bottom waters of Lake Superior, which are shown in Figures 4.1-1 and 4.1-2. The results of four separate cruises from 1970-76, are shown in Table 4.1-2 (109). Histograms of trace metal concentrations determined in the open waters during 1973 are noted in Figure 4.1-3. Analyses for trace metals in waters of Lake Superior nearshore areas are shown in Tables 4.1-1 and 4.1-3 (98, 109, 110).

The waters of 16 tributaries to Lake Superior were studied during 1971-72 by Wagner and Lemire (111). The result of their analyses for filterable metals in waters are shown in Table 4.1-4. Total loadings of metals to Lake Superior via tributaries, as calculated by the ULRG, are given in Table 4.1-5. Additional tributary data was obtained from STORET data system (110).

The Upper Lakes Reference Group, on the basis of its data on metal levels in Lake Superior waters, reported that "cadmium, chromium and cobalt are rarely present above the detection limit of 0.2 μg/L." Other elements such as copper, nickel, zinc and lead are uniformly low. With regard to copper, "in the nearshore areas, elevated mean concentrations of copper were found in unfiltered water samples from the Upper or Lower Portage Entries (7.0 and 4.2 μg/L respectively)." Elevated copper concentrations at those locations as well as within the Ontonagon and Carp Rivers, were considered to be as a result of copper mining activities and erosion of copper ore deposits. Data for nickel was scattered (from 1 to 3.8 μg/L), due also to its presence in regional bedrock.

Organic Contaminants

Table 4.1-6 summarizes data on ppb levels of organic contaminants in the open waters and nearshore areas of Lake Superior.

Within the open waters, Glooschenko and Strachan in 1974 could not detect any organochlorine pesticides, PCBs or organophosphorus pesticides above levels shown in Table 3.1-7 (12). However, traces of lindane were indicated. Swain in 1977 (112), reported PCB levels in the open waters of Lake Superior to be 0.005 μg/L during 1974. Table 4.1-7 which is taken from Swain's paper, shows the significance of airborne contamination in that Siskiwit Lake, which is within Isle Royale, contains PCB levels in the order of 0.16 ppb.

Levels of organic contaminants in nearshore waters, which are shown in Tables 4.1-6 and 4.1-8, were obtained from references 110 and 113-115. Table 4.1-9 gives the results of a study (115) to evaluate the residues of PCBs and DDT within various components of the ecosystem (i.e. water, sediments, zooplankton, fish). A study by Fox (116, 117) evaluated the concentrations of dissolved organic compounds in the waters of the Nipigon River and Nipigon Bay. This information is presented in Table 4.1-10. Vert Island is approximately 20 km from a paper mill, and samples from the area were considered to represent a background profile for dissolved organic compounds in Nipigon Bay. The Nipigon River was used for log drives to the paper mill for many years.

Additional data for organic contaminants in tributary waters to Lake Superior are shown in Table 4.1-11 (110).

TABLE 4.1-1

HEAVY METAL CONCENTRATIONS IN WATERS OF LAKE SUPERIOR

ppb (μg/ℓ)[a]

Date	Stations	No. Samples	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn	Information Source
1970-71	Lakewide (See Figures 4.1-1 and 4.1-2)	226							.18±.13 (0-.47)							4
1970-76	Lakewide (See Table 4.1-2)	24		✓	✓		✓	✓	✓		✓				✓	109
1974	Black River						3±3	<5							9±16	98
1974	Ontonagon	24					3±3	<5							7±13	98
1974	Upper Portage Entry	12					3±2	<5							4±2	98
1974	Lower Portage Entry	12					8±7	<5							6±6	98
1974	Eagle Harbor	12					6±5	<5							7±9	98
1974	Isle Royale	10					4±3	<5							5±3	98
1974	Big Bay	24					6±4	<5							11±6	98
1974	Presque Isle	24					4±3	<5							10±6	98
1974	Carp River	24					3±3	<5							9±7	98
1974	Munising	24					3±1	<5							10±4	98
1974	Grand Marais	24					3±1	<5							10±9	98
1974	Whitefish Point	24					3±3	<5							8±4	98
1975	13 Stations (See Table 4.1-3) (nearshore)		✓	✓	✓		✓	✓	✓		✓				✓	98,109
1973-77	Ironwood Twp. Mouth, Montreal River	9	<.1-2[b]	.5-2	-		1-7[b]	.1-6	<.2-.2		<5-30	<1-3[b]	<1-3[b]		8-36[b]	110
1973-77	Whitefish Twp. Mouth, Tahquamenon River	9					<1-4[b]	<1-6	<.1-1.3		8-9	<1-2[b]	<1-2[b]		6-55[b]	110
1973-77	Munising WTP Water Intake	8	<1	.2-1[b]	<1-5		3-8[b]	<1-11[b]	<.1-1.2	-	2-4	<2	<1		160-185	110
1973-77	White Pine Mine, WTP Water Intake	10	<.2-1	<.1-1	<1-39		.4-20	<1-3	<.1-1	-	<5-11	<2	<1-2[b]		1-36[b]	110

(a) "total" unless otherwise specified

(b) dissolved fraction

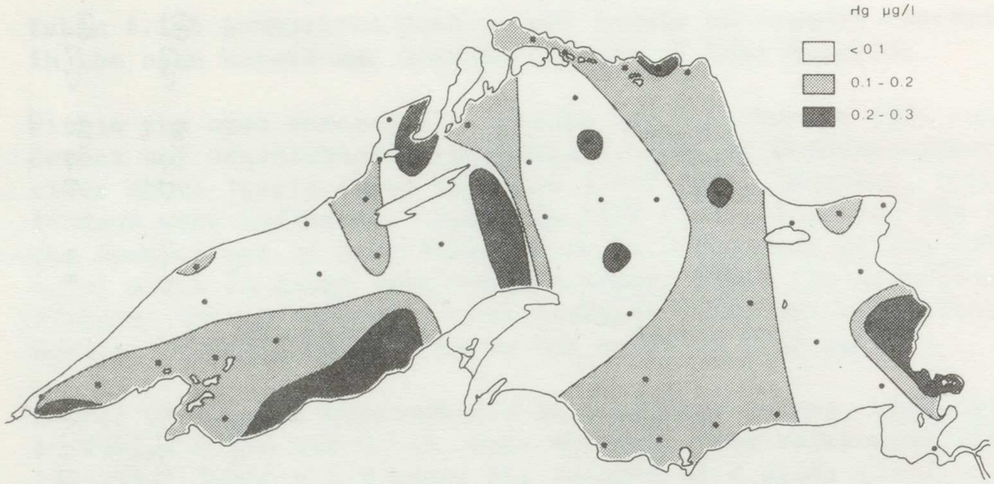


FIG. 4.1-1 The average distribution of total mercury in the surface waters of Lake Superior (1970-1971). Dots represent sampling stations.

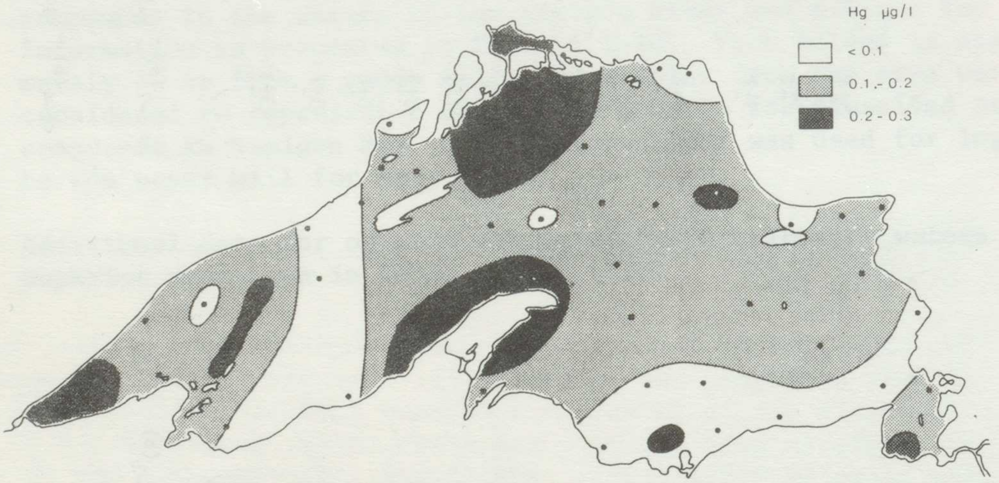


FIG. 4.1-2 The average distribution of total mercury in the bottom waters of Lake Superior (1970-1971). Dots represent sampling stations.

TABLE 4.1-2

MEAN CONCENTRATIONS OF HEAVY METALS IN LAKE SUPERIOR, BY CRUISE[a]

	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Ni	Zn
1970										
Apr. 15-23	-	-	0.55	2.11	5.81	1.54	0.33			4.5
Oct.26-Nov.10	-	-		1.8	4.8	1.8	-	-		
1971										
May 25-June 2	0.37	0.23	-	6.95	3.02	1.29	0.35		1.26	14.4
June 30-July 7	0.40	-	-	2.00	1.69	1.42	0.28		1.00	4.1
Oct. 5-13	-	0.27	-	6.52	1.69	1.19	0.40		-	8.0
1973										
May 12-22	-	-	-	3.17	3.14	-	0.43	0.10	1.01	8.5
June 16-27	0.30	-	-	2.59	2.64	1.00	0.41	0.05	3.83	16.2
July 27-Aug.7	-	-	-	1.93	1.66	-	0.32	0.09	1.13	20.7
Sept. 6-16	-	-	-	0.72	2.17	-	0.33	0.07	-	8.0
Oct. 14-25	-	-	-	1.24	1.14	-	-	0.06	-	11.3
Nov. 14-28	-	0.25	-	4.95	1.16	1.75	0.34	0.05	2.42	25.8
1976										
June 7-19				0.95	1.23	1.00			1.00	3.3

a. Spaces left blank indicate no analyses were done. The dash (-) indicates below detection limit. Concentrations in μg/ℓ. All samples filtered except for Hg.

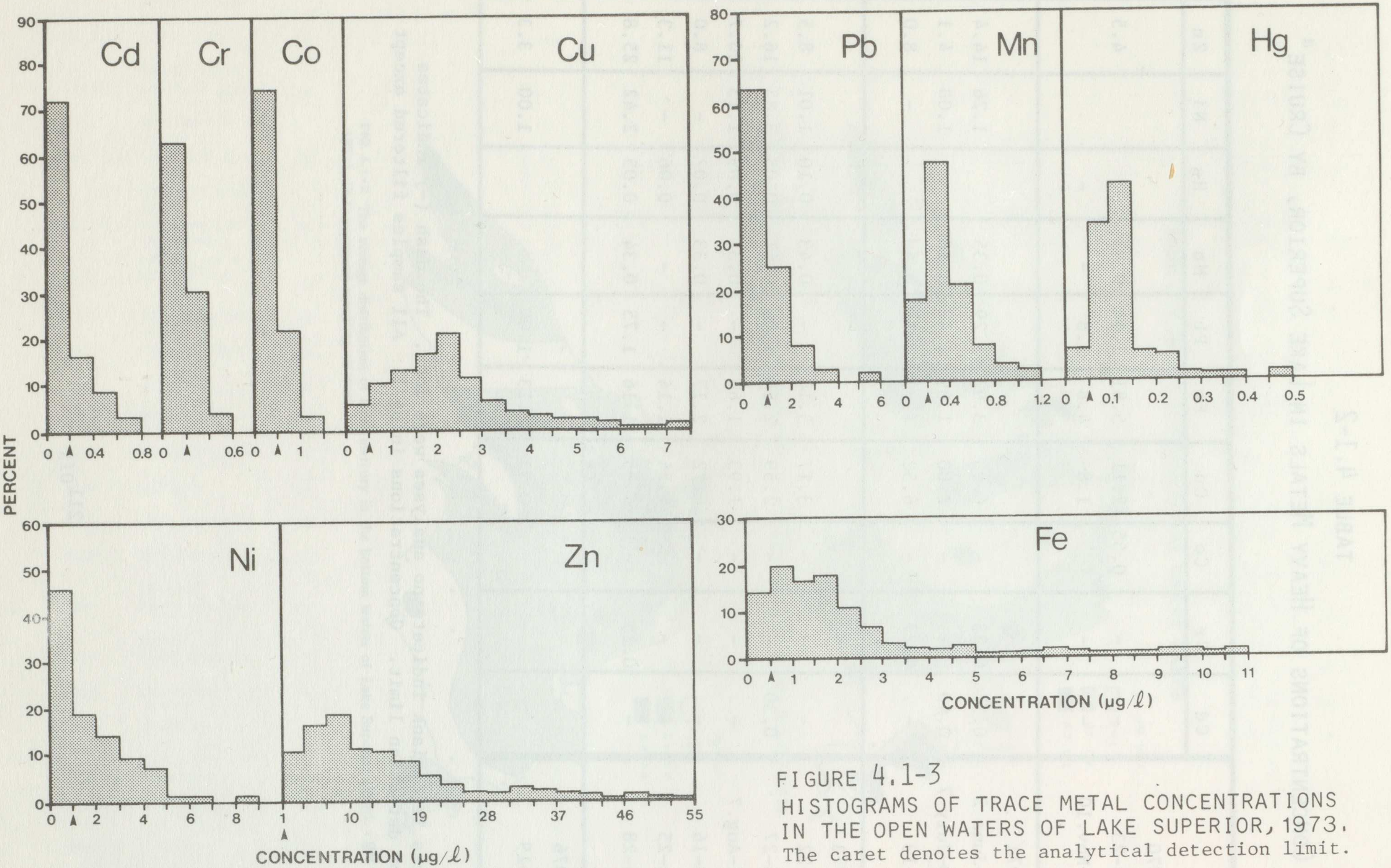


FIGURE 4.1-3
HISTOGRAMS OF TRACE METAL CONCENTRATIONS IN THE OPEN WATERS OF LAKE SUPERIOR, 1973.
The caret denotes the analytical detection limit.

TABLE 4.1-3

HEAVY METALS IN LAKE SUPERIOR WATERS

LOCATION	SAMPLE TYPE[a]	n[b,c]	CONCENTRATION IN $\mu g/\ell$[d] As	Cd	Cr	Cu	Fe	Hg[e]	Mn	Ni	Pb	Zn
BLACK RIVER	UF	1	0.9	0.09	0.5	1.7	19	<0.02	0.6	<0.8	0.5	<2.3
	F	1	0.9	f	<0.4	0.8	0.8		0.3	<0.8	<0.2	f
ONTONAGON	UF	1	0.9	0.15	0.4	1.5	30	<0.02	0.6	<0.8	0.4	<1.6
	F	1	0.6	f	<0.3	1.0	2.0		f	<0.8	<0.2	f
U. PORTAGE ENTRY	UF	1	0.8	0.04	<0.3	1.3	43	<0.02	0.6	<0.9	0.2	<1.7
	F	1	0.7	<0.03	<0.3	0.9	0.6		0.3	<0.8	<0.2	f
L. PORTAGE ENTRY	UF	1	0.8	0.11	0.3	1.9	8.9	<0.02	0.6	<0.8	0.3	4.4
	F	1	0.7	0.11	<0.03	0.8	<1.4		f	<0.8	<0.2	f
EAGLE HARBOR	UF	2			0.3						0.2	<2.0
			0.8	0.11	<0.3	1.2	46	<0.02	0.8	<0.8	<0.2	<1.5
	F	2					0.8					
			0.7	0.04	<0.3	0.7	<0.5		0.2	<0.8	<0.2	1.3
BIG BAY	UF	2										<2.7
			0.9	0.16	1.0	2.0	10.0	<0.02	0.5	<0.8	0.4	2.6
	F	2					1.6		0.2			
			1.1	0.09	0.3	1.2	<0.5		<0.1	<0.8	<0.2	f
MARQUETTE HARBOR	UF	2		0.08							0.4	<2.5
			0.9	<0.04	0.4	1.1	20.1	<0.02	1.4	<0.8	<0.2	<1.8
	F	2		0.11		<1.1	6.6		<0.2			
			1.2	<0.03	<0.3	<1.0	<0.5		0.1	<0.8	<0.2	f
CARP RIVER	UF	1	0.7	0.06	<0.3	1.3	6.0	<0.02	0.6	<0.8	0.4	<1.0
	F	1	0.7	f	<0.3	f	1.2		0.5	<0.8	<0.2	f
PRESQUE ISLE	UF	1	0.7	0.05	<0.3	0.9	7.0	<0.02	0.3	<0.8	<0.3	<1.1
	F	1	0.6	f	f	0.5	<0.5		f	<0.8	<0.2	f
MUNISING	UF	1	0.8	0.06	0.5	1.7	8.6	<0.02	0.7	<0.8	0.4	<2.1
	F	1	0.7	<0.03	<0.4	0.6	1.7		f	<0.8	<0.2	<1.0
GRAND MARAIS	UF	2			0.4							5.1
			0.8(8)	0.27(8)	<0.3(8)	1.9(8)	5.2(8)	<0.03	0.4(8)	<0.8(9)	<0.6(8)	<2.7(8)
	F	2			<0.4	<1.6	<1.7				0.4	<4.0
			0.7(3)	0.17(3)	<1.0(3)	<1.0(3)	<0.7(3)		<0.05(3)	<0.8(3)	<0.2(3)	<3.0(3)
WHITEFISH POINT	UF	1	0.8(5)	0.08(5)	0.4(5)	1.8(5)	10.3(5)	<0.04	0.5(5)	<0.9(5)	0.4(5)	2.4(5)
	F	1	0.7(2)	0.03(2)	<0.3(2)	<1.6(2)	1.5(2)		f	<0.8(2)	<0.2(2)	0.7(2)
CASCADE RIVER	UF+F	20	7.7	0.05	4.6			0.22	2.0	5.5	0.4	
			<1.0	<0.01	<0.3	1.5	12.9	<0.10	0.08	<1.0	<0.1	3.5
GOOSEBERRY RIVER	UF+F	22	3.9	<0.05	3.5			0.17		3.5	<0.2	
			<1.0	<0.01	<0.2	1.7	91	<0.10	4.0	<1.0(21)	<0.1	6.6
DULUTH	UF+F	24	3.1	0.22	4.0			0.15		6.3	4.5	
			<1.0(23)	<0.01	<0.3	1.5(23)	127	<0.10	4.6(23)	<1.0	<0.1	10.1
MINNESOTA POINT	UF	2	f	2	10	15	420	0.3	f	10	10	280
MIDDLE RIVER	UF	2	f	2	30	10	500	0.3	f	10	10	20
ASHLAND	UF	2	f	2	10	6	240	0.3	f	10	10	10
SAXON HARBOR	UF	2	f	2	20	7	120	0.3	f	10	10	10

a. UF: unfiltered; F: filtered (0.1 µm membrane); UF+F: mean includes both sample types.

b. For Michigan data, each UF sample (n) represents a composite of three individual samples.

c. If the number of sample is different from n shown, the total number of individual samples is shown in brackets after the individual result for the parameter.

d. If two values are shown, a mean could not be obtained and the range is shown.

e. Michigan Data - mercury analysis was carried out on a single unfiltered sample for each location.

f. Data not available.

TABLE 4.1-4

HEAVY METALS IN WATERS OF TRIBUTARIES TO LAKE SUPERIOR (μg/L)[a]

	Station	No. Samples	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn	Information Source
	RIVER															
1971-72[b]	St. Louis	13		0.5 (<0.2-1.8)			2.1 (1.3-3.1)	2 (4-5)			5 (4-8)				6 (3-12)	111
	Lester	13		0.2 (<0.2-0.4)			3.3 (2.4-6.4)	2 (4-5)			3 (4-6)				3 (1-8)	
	Knife	13		0.3 (<0.2-0.8)			2.4 (2.1-6.1)	1 (<1-4)			3 (4-5)				3 (1-9)	
	Stewart	13		0.2 (<0.2-0.4)			2.4 (1.7-4.2)	2 (4-3)			3 (4-5)				2 (1-5)	
	Split Rock	13		0.2 (<0.2-0.5)			2.0 (0.9-3.6)	2 (4-3)			3 (4-5)				2 (1-4)	
	Beaver	13		0.2 (<0.2-0.3)			2.0 (0.9-3.2)	1 (<1-3)			3 (4-7)				4 (4-9)	
	Baptism	13		0.2 (<0.2-0.3)			1.4 (<0.5-2.3)	2 (<1-5)			4 (<1-11)				4 (1-13)	
	Manitou	13		0.2 (<0.2-0.5)			1.0 (<0.5-1.4)	1 (<1-5)			5 (<1-10)				3 (<0.5-7)	
	Caribou	13		<0.2			1.2 (<0.5-2.3)	1 (<1-2)			4 (<1-8)				3 (<0.5-6)	
	Cross	12		0.2 (<0.2-0.4)			1.1 (0.7-1.8)	1 (<1-3)			4 (<1-10)				3 (<0.5-7)	
	Temperance	13		0.2 (<0.2-0.5)			1.4 (<0.5-2.4)	1 (<1-4)			4 (<1-10)				2 (<0.5-5)	
	Cascade	13		0.2 (<0.2-0.5)			1.3 (<0.5-2.2)	1 (<1-4)			3 (<1-7)				3 (<0.5-8)	
	Devil's Track	13		0.2 (<0.2-0.3			1.3 (<0.5-1.9)	1 (<1-2)			3 (1-8)				4 (0.5-7)	
	Brule	13		0.2 (<0.2-0.5)			1.3 (<0.5-2.0)	1 (<1-4)			3 (<1-8)				3 (<0.5-6)	
	Reservation	13		0.2 (<0.2-0.5)			2.8 (<0.5-4.4	1 (<1-2)			3 (<1-6)				3 (0.5-7)	
	Pigeon	12		0.3 (<0.2-0.6)			1.5 (1.5-7.8)	2 (<1-8)			3 (<1-6)				5 (1-19)	
1973-77	Mineral R. Carp Lake Twp	10	<1-7[b]	0.4-10[b]			16-76[b]	8-300[b]	<0.2		10-51	<1-2[b]	<1-3[b]		27-79[b]	110
1973-77	Ontonagon R. Ontonagon Twp	8	0.5-1[b]	0.4-2			3-6[b]	1-200[b]	<0.2		6-17[b]	<1-2[b]	<1-2[b]		8-55[b]	110
1974-76	Ontonagon R Rockland Twp	3	<1	0.4			2	2	<0.2		8-12[b]	<2	<1-1.4		5-15[b]	110
1973-77	Presque Isle R Wakefield Twp	8	0.3-0.4[b]	<0.1-2			<1-4[b]	2-3	<0.2-0.1		10-82	<1-4[b]	<1-5.8[b]		2-30[b]	110

a) "total" unless otherwise specified

b) "dissolved"

TABLE 4.1-5

TRIBUTARY INPUTS TO LAKE SUPERIOR

JULY 1973 - JUNE 1975

Parameter	Mean Loading (kg/d)		
	Sampled Basin	Unsampled Basin	Total
Alkalinity as $CaCO_3$	1,910,000	1,110,000	3,020,000
Arsenic	1,120	170	1,290
Barium	5,200	1,850	7,050
BOD (5 Day @ 20°C)	281,000	59,600	340,000
Cadmium	793	169	962
Calcium	2,660,000	612,000	3,270,000
Carbon, Total Organic	1,960,000	523,000	2,490,000
Chemical Oxygen Demand	5,030,000	1,250,000	6,280,000
Chloride	518,000	63,200	581,000
Chromium	1,700	468	2,170
Copper	1,780	998	2,780
Cyanide	974	310	1,280
Fluoride	16,700	5,970	22,600
Iron	129,000	49,900	179,000
Lead	2,010	1,020	3,030
Magnesium	844,000	146,000	990,000
Manganese	4,760	1,860	6,620
Mercury	29.3	13.2	42.5
Nickel	1,182	501	1,680
Nitrogen, Total as N	79,500	20,600	100,000
Nitrogen, Organic as N	56,000	15,000	71,000
Nitrogen, Ammonia as N	8,130	2,100	10,200
Nitrogen, NO_3 + NO_2 as N	15,200	3,410	18,600
Oil - Grease	153,000	34,400	187,000
Pesticides	1.12	1.87	2.99
Phenols	539	186	725
Phosphorus, Total as P	5,780	1,990	7,760
Phosphorus, Reactive PO_4 as P	1,200	559	1,760
Phthalates	0.680	Not Sampled	0.680
Polychlorinated Biphenyl	3.16	1.61	4.77
Potassium	185,000	50,200	236,000
Selenium	110	74.0	184
Silicate, Reactive as SiO_2	828,000	300,000	1,130,000
Sodium	428,000	109,000	537,000
Solids, Total	16,200,000	4,820,000	21,000,000
Solids, Dissolved	12,500,000	3,960,000	16,400,000
Solids, Particulate	3,060,000	1,110,000	4,170,000
Sulfate as SO_4	1,130,000	296,000	1,430,000
Zinc	2,720	1,040	3,760

The totals shown above represent all available data. However, some discharges were not sampled for all parameters, and some analytical techniques varied among the four jurisdictions.

TABLE 4.1-6

ANALYSES FOR ORGANIC CONTAMINANTS IN THE WATERS OF LAKE SUPERIOR

Location	Sampling Period	No. Samples	Organic Substances Detected and Quantified (µg/L)	Date Detection	Quantification Limit µg/L	Source
Munising WTP[a] Water Intake - Lake Superior	1974-76	5	Diethylhexyl phthalate 2	01/76	1	110
White Pine Mine WTP[a] Water Intake - Lake Superior	1975-76	4	None	-	-	110
Mouth Montreal River[a][b]	1973-75	6	o, p - DDT, 0.001 p, p - DDT, 0.025	08/74	0.001	110
Mouth Carp River[a] (Marquette)		6	Aroclor 1254, 1.6 o, p - DDT, 0.07 p, p - DDT, 0.2 DBP, 12.0 DEHP, 3.0 o, p - DDT, 0.04 p, p - DDT, 0.045	08/73 08/73 08/73 08/73 08/73 08/74 08/74	0.1 0.01 0.01 1.0 0.001	110
Mouth Tahquamenon River[a] Whitefish Twp.	1973-75	6	o, p - DDT, .003 p, p - DDT, 0.02	08/74 08/74	.001 .001	110
Various nearshore and Tributary stations	1971-75		Aldrin, Dieldrin, DDT Heptachlor, Lindane, PCBs, Endrin, Chlordane, and Methoxychlor (See Table 4.1-8)			113
Nearshore Waters	1972-73		PCB, 0.0008 (See Table 4.1-9)			115

TABLE 4.1-6 CONT'D

ANALYSES FOR ORGANIC CONTAMINANTS IN THE WATERS OF LAKE SUPERIOR

Location	Sampling Period	No. Samples	Organic Substances (μg/L) Detected and Quantified	Date Detection	Quantification Limit μg/L	Source
Nearshore and Open Waters 17 sites	1974		Traces of Lindane (~10% of quantification limit). Other organochlorines and organophosphorus cpds not detected (See Table 3.1-7)		0.005	12
Duluth Area	1974		Lindane - 0.002 BHC - 0.005 PCB - 0.029			114
Open and Nearshore Waters	1974-76		PCB (0.005-0.02) (See Table 4.1-7)			112
Nipigon Bay	1974		Natural dissolved organics components (See Table 4-1-10)			116
Isle Royale						
Washington Harbor	1976		PCB (0.05)	01/76		112
Robinson Bay	1976		PCB (0.12)	01/76		
Siskiwit Lake	1976		PCB (0.16)	01/76		

(a) Substances sought and quantification limits (μg/ℓ) include: Dieldrin (0.001), o, p - DDT (0.001), p, p - DDT (0.001), DBP (1.0), Toxaphene (1.0), Chlordane (0.05), 2, 4-D (0.05), Silvex (0.5), Endrin (0.01), Heptachlor (0.005), Lindane (0.005), Methoxychlor (0.05), PCBs (0.1).

(b) Detection levels varied considerably.

TABLE 4.1-7
(Ref. 112)

POLYCHLORINATED BIPHENYL COMPOUNDS OBSERVED IN WATER AT VARIOUS LOCATIONS IN LAKE SUPERIOR AND IN THE VICINITY OF ISLE ROYALE

Location	Depth (m)	Date	PCB as Aroclor 1254 µg/ℓ
1. Open Waters,[1] Western Lake Superior	50-65	December 1976	0.005
2. Open Waters, Lake Superior	10	November 1974	0.005
3. Nearshore Waters Lake Superior at Duluth Water Intake	0.5	November 1974	0.007
4. Nearshore Waters-Western Lake Superior	0.5	January 1976	0.010
5. Duluth-Superior Harbor,[2] Howard Bay	1-8	January 1976	0.020
6. Washington Harbor, Isle Royale	0.5	January 1976	0.050
7. Robinson Bay, Isle Royale	0.5	January 1976	0.120
8. Siskiwit Lake, Isle Royale	0.5	January 1976	0.157
COMPARATIVE DATA, VEITH <u>et al</u>. 1977			
Nearshore Waters, Lake Superior[3], at ERL-D Laboratory Intake	10	1972-73	0.0008

[1] Mount, D. I. 1976. Summary of Water Analyses Pertinent to the Barrels in Lake Superior; Environmental Research Laboratory-Duluth; Press Release.

[2] Swain, <u>et al</u>. 1975. <u>Evaluation of the Effects of a Harbor Bubbler System for Winter Navigation on the Water Quality of Howard's Bay in the Duluth-Superior Harbor - Winter 1974-75</u>. Final Report to the United States Army Corps of Engineers.

[3] Veith, <u>et al</u>. 1977. Residues of PCBs and DDT in the Western Lake Superior Ecosystem. <u>Archives of Environmental Contamination and Toxicology</u> <u>5</u>: 487-499.

TABLE 4.1-8

(Ref. 113)

SUMMARY OF STORET DATA - ORGANOCHLORINES IN NEARSHORE AND TRIBUTARY WATER SAMPLES

Organochlorine Compounds	Place and Sample Date	Mean µg/ℓ	Maximum µg/ℓ	Number of Samples	IJC Water Quality Objective µg/ℓ
Aldrin + Dieldrin*	Mich. 1973-5	0.040	0.44	90	0.001
	Wisc. 1974-5	0.008	0.02	16	
Total DDT residues*	Mich. 1971-5	0.063	0.68	110	
	Wisc. 1974-5	0.022	0.08	16	0.003
	Minn. 1967-75	0.032	0.10	93	
Heptachlor + heptachlor epoxide*	Mich. 1973-5	0.038	0.37	90	0.001
	Wisc. 1974-5	0.005	0.01	16	
Lindane	Mich. 1973-5	0.008	0.04	90	0.01
	Wisc. 1974-5	0.002	0.005	16	
PCBs	Mich.†1971-5	0.15 (0.40)	0.98 (2.0)	84 (26)	
	Wisc. 1974-5	0.05	0.30	16	0.001 @
	Minn. 1972-5	0.11	1.2	160	
Endrin	Mich. 1973-5	0.043	0.52	90	0.002
Chlordane	Mich. 1973-5	0.059	0.32	89	0.06
Methoxychlor	Wisc. 1974-5	0.015	0.02	16	0.04

* Values refer to the sums of the means and of the maxima for the substances and its degradation products.

† Parenthesis values refer to 1242 + 1254 reported as well.

@ An indicated maximum, not an accepted objective.

TABLE 4.1-9

RESIDUES OF PCBs AND DDT IN THE WESTERN LAKE SUPERIOR ECOSYSTEM[(a)]

Sample (specimen)	Sampling Location	Concentrations PCB (as Aroclor 1254) ppm[b]	ΣDDT ppm[b]	Dieldrin ppm[b]
Water	Environmental Research Laboratory-Duluth water supply inlet	0.8±0.4 ng/L		
Sediments	5 miles from Silver Bay, Minn. (270 m depth)	7.0±0.5ppb		
Zooplankton (*Mysis relicta*)	North shore vicinity	0.05-0.12	0.04-0.05	2ppb
Slimy sculpin	Little Two Harbors, Illgen City, Grand Marais	0.18-0.34	0.006-0.12	
Fourhorn sculpin	Illgen City, Grand Marais, Grand Portage	0.12-0.45	0.2-0.64	
Burbot	Apostle Island Region	1.0-1.7	0.2-0.6	0.03
	Little Two Harbors Region	<0.9-1.0	0.08-0.8	<0.03
	Illgen City Region	0.5-1.2	0.5-1.3	<0.03
Lake Trout	Apostle Island Region	0.3-5.6	0.1-12.8	<0.03-0.05
	Little Two Harbors Region	<0.3-1.5	0.2-1.5	<0.03
	Illgen City Region	0.3-1.2	0.3-1.7	<0.03
	Grand Marais	1.9	0.8	-
Rainbow smelt	Apostle Island Region	0.4-0.5	0.2-0.3	<0.03
	Little Two Harbors Region	<0.4-1.2	0.1-0.7	<0.03
	Illgen City Region	0.2-0.5	0.2-0.5	<0.03

(a) Veith, G.D., D.W. Kuehl, F.A. Puglisi, G.E. Glass and J.G.Eaton. Archives of Environmental Contamination and Toxicology 5, 487 (1977).

(b) Concentrations in ppm unless otherwise indicated.

TABLE 4.1-10

(Ref. 116,117)

Dissolved organic compounds and concentrations in μg/L found off Vert Island at 1 m (Nipigon Bay background profile for dissolved organic compounds) and Nipigon River water (Principal source of input to Nipigon Bay other than the Red Rock Mill).

Compound	Approximate Concentrations (μg/L) Detected off Vert Island 1 m	Approximate Concentrations (μg/L) Detected in Nipigon River mouth 1 m
Lauric acid	–	5
Myristic acid	5	10
Pentadecanoic acid	5	5
Palmitoleic acid	20	15
Palmitic acid	30	40
Heptadecanoic acid	20	2
Linoleic acid	1	–
Oleic acid	20	30
Stearic acid	10	20
2-methyl octadecanoic acid	1	–

TABLE 4.1-11

ANALYSES FOR ORGANIC CONTAMINANTS IN TRIBUTARY WATERS TO LAKE SUPERIOR (a)

ORGANIC SUBSTANCES SOUGHT AND DETECTION LIMITS (b) (μg/L)

Aldrin:	0.001-0.01	Chlordane:	0.01-0.32
Dieldrin:	0.001-0.09	Endrin:	0.005-0.13
o,p-DDT:	0.001-0.02	Heptachlor:	0.001-0.01
p,p-DDT:	0.005-0.02	Lindane:	0.001-0.01
Diethylhexyl phthalate (DEHP):	1.0	PCBs:	0.02 -0.49
		Aroclor 1254:	0.1

Location	Sampling Period	No. Samples	Organic Substances Detected and Quantified (μg/L)	Date
Mineral River (Carp Lake Twp)	1973-75	6	o,p-DDT,- 0.002	08/74
			p,p-DDT - 0.01	08/74
Ontonagon River (Ontonagon Twp)	1973-75	5	p,p-DDT - 0.022	12/73
			Dieldrin- 0.001	08/74
			o,p-DDT - 0.05	08/74
			p,p-DDT - 0.12	08/74
			Endrin - 0.02	08/74
Presque Isle River (Wakefield Twp)	1973-75	5	o,p-DDT - 0.002	08/74
			p,p-DDT - 0.01	08/74

(a) Michigan Department of Natural Resources data
(b) Detection Limits varied considerably

4.2 DATA ON SEDIMENT QUALITY

Heavy Metals

Data on heavy metal concentrations in Lake Superior sediments are summarized in Table 4.2-1.

In 1971, Smith and Moore (118) evaluated the distribution of trace metals in surficial sediments around Keweenaw Point which is the location of considerable past mining activities, particularly in the 1860's. The distributions of zinc and copper in the area are shown in Figures 4.2-1 and 4.2-2. In 1972, Fitchko and Hutchinson (32) evaluated the sediment quality at the mouths of 24 tributaries to Lake Superior. The results are shown in Table 4.2-2.

Subsequently, as part of the Upper Lakes Reference Group study, Kinkead and Chatterjee (119) evaluated the distribution of heavy metals in the surficial sediments within the Canadian nearshore zone of Lake Superior. Some data from the study are shown in Figures 4.2-3 to 4.2-5. In 1977, the ULRG (109) summarized the results of many Lake Superior sediment studies, and these are shown in Tables 4.2-3 and 4.2-4 and Figure 4.2-6. The results of the PLUARG studies (28) indicated a (total lake) average of 49 ppm lead within the sediments of Lake Superior (Table 4.2-5 and Figure 1.2-8 and 1.2-9).

Extensive discussions on the Lake Superior sediment characteristics are found within the ULRG report (109). In part, the Reference Group has stated that "trace metals are generally low, exclusive of Thunder Bay, though there is evidence that Hg and Pb, and possibly Cu, are being elevated by man's activities. There is further evidence that relatively high levels (when compared to Lake Huron) of Cu, Zn and Ni occur in sediments of Lake Superior, due to regional mineralization occuring in the bedrock of the area."

Organic Contaminants

The results of several studies to evaluate the levels of organic contaminants in Lake Superior sediments are shown in Table 4.2-6. Kinkead and Chatterjee (119) generally found low levels of DDE, DDD, DDT, PCBs and diethyl hexyl phthalates. However, a concentration of 250 μg/kg PCBs was found in the vicinity of Marathon. The investigation could not detect lindane, heptachlor, aldrin, heptachlor epoxide, thiodan, dieldrin or endrin. Glooschenko, Strachan and Sampson (12) indicated that most organochlorine compounds and all organophosphorus compounds were below detection levels. However, two high levels of PCBs were found - 1.3 ppm near Marathon, Ontario and 90 ppb at one station located at the middle of the lake.

Table 4.2-7 summarizes the organic contaminants found in Lake Superior sediments during the ULRG study. The Reference Group also noted that samples from Munising Bay, Michigan had elevated levels of diethyl hexyl phthalate (1400-4100 μg/kg) and from 1500 - 61,000 mg/kg of hexane extractable oils and grease. Brownlee and Strachan (121) evaluated the fate of pulp mill effluents, by determining concentrations of the effluent components in water, seston and sediments. Significant amounts of dehydroabietic acid were found 1 km from the source.

TABLE 4.2-1

LAKE SUPERIOR SEDIMENTS - METAL ANALYSES

SAMPLE DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	CONCENTRATION - ppm dry weight								INFORMATION SOURCE
			MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	
1971	Keweenaw Point - north - south (See Figures 4.2-1 and 4.2-2)				 80 57	 54 31				 160 32	118
1972	Mouths of 24 Rivers (See Table 4.2-2)		✓	✓	✓	✓		✓	✓	✓	31
1973	Entire Lake + 10 Subbasins (See Table 4.2-3)										109
1973	Entire Lake - surficial sediments (See Table 4.2-4 and Figure 4.2-6)		✓	✓	✓	✓		✓	✓	✓	109
1973	Nearshore - Canadian side (See Figures 4.2-3 to 4.2-4)	67	✓	✓	✓	✓		✓	✓	✓	119
1973	Peninsula Harbor (See Figure 4.2-5)	52	✓								119

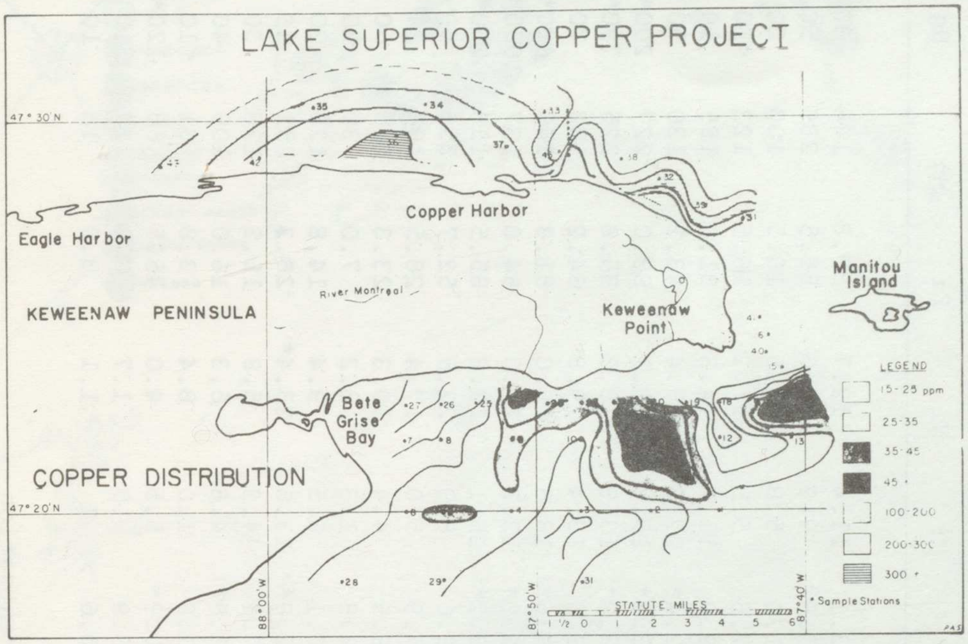


Fig.4.2-1 Dispersion of copper (total) around Keweenaw Point (1 statute mi = 1.609 km).

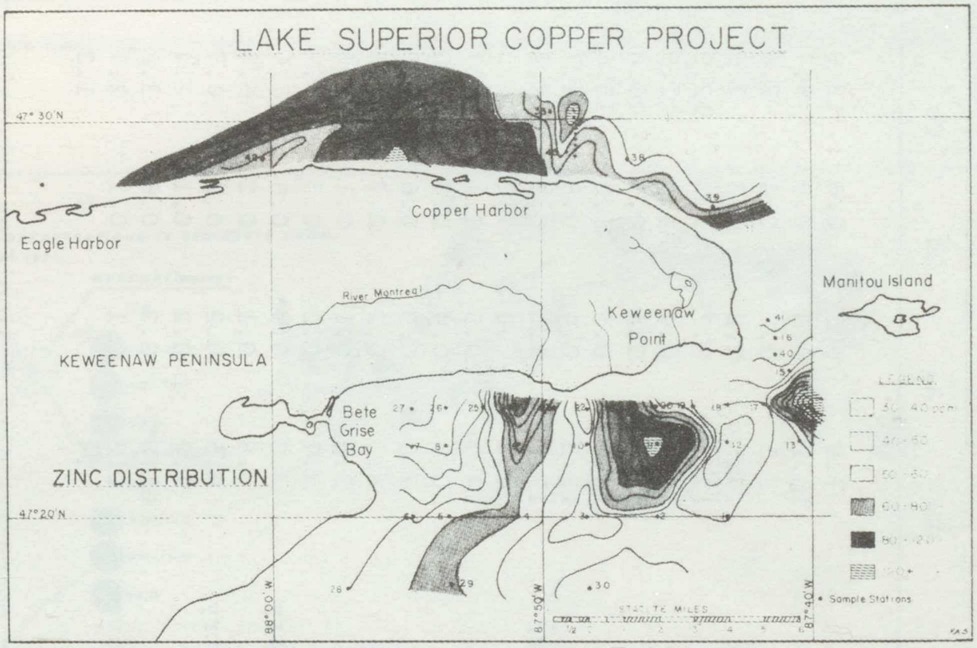


Fig.4.2-2 Dispersion of zinc (total) around Keweenaw Point (1 statute mi = 1.609 km).

TABLE 4.2-2

Concentration of heavy metals in outlet sediments of Lake Superior tributaries.

	Concentration (ppm)									(ppb)
Site	Pb	Ag	Cd	Co	Cu	Cr	Ni	Zi	Mn	Hg
Goulais River	7.8	0.3	0.6	13.0	13.1	11.4	12.7	30.8	148	30
Batchawana River	10.2	0.3	0.9	9.7	13.8	9.8	12.6	55.5	239	50
Montreal River	5.5	0.2	0.4	7.8	11.0	5.8	10.5	18.5	100	20
Michipicoten River	3.5	0.2	0.3	7.6	7.5	5.9	11.2	16.5	123	<10
Pic River	12.3	0.7	1.3	12.9	9.9	11.0	14.8	31.0	155	10
Nipigon River	31.2*	0.4	0.8	11.9	22.4*	22.8*	18.4	43.2	130	50
Current River	40.3*	0.4	0.9	16.6	23.3*	13.8	21.1	83.0	227	200*
McIntyre River	26.6	0.5	1.0	15.6	29.9*	13.8	18.3	85.8	225	790**
Neebing River	12.3	0.4	0.8	14.7	19.8	13.4	19.8	64.2	183	70
Kaministikwia River	17.5	0.5	0.9	14.2	28.5*	13.6	19.0	81.8	140	480*
McKellar River	14.0	0.4	1.0	16.3	24.0*	12.2	21.0	84.0	137	1050**
Mission River	14.7	0.5	1.1	15.7	33.2*	16.1	19.8	85.5	125	690**
Pigeon River	10.5	0.4	0.7	18.0*	19.6	8.9	22.5	52.7	353	50
Devil Track River	7.0	0.3	0.6	16.0	17.9	5.0	17.4	28.5	192	30
Black River	8.3	0.2	0.3	8.8	8.5	4.4	10.3	23.3	205	60
Big Iron River	2.0	0.1	0.1	3.6	8.8	1.3	3.2	7.0	39	30
Ontonagon River	3.7	0.2	0.3	7.3	10.1	6.5	9.4	14.8	122	20
Keweenaw Upper Entry	7.0	0.9*	0.6	17.0	262.8**	13.6	33.4*	28.3	251	50
Portage Lake	3.8	0.1	0.2	6.4	7.1	4.2	5.8	15.3	128	30
Keweenaw Lower Entry	4.5	0.2	0.3	6.7	22.8*	4.8	6.3	16.0	109	40
Dead River	1.2	0.2	0.1	2.4	1.8	1.0	8.4	3.8	31	<10
Anna River	61.8*	0.2	0.6	3.8	20.9*	5.5	4.0	45.5	63	120*
Big Two Hearted River	2.8	0.1	0.1	2.7	0.9	0.9	1.7	3.0	27	<10
Tahquemenon River	T[2]	T	T	1.2	0.6	T	1.1	3.0	18	10

*Signifies elevated concentration; **Signifies excessive concentration

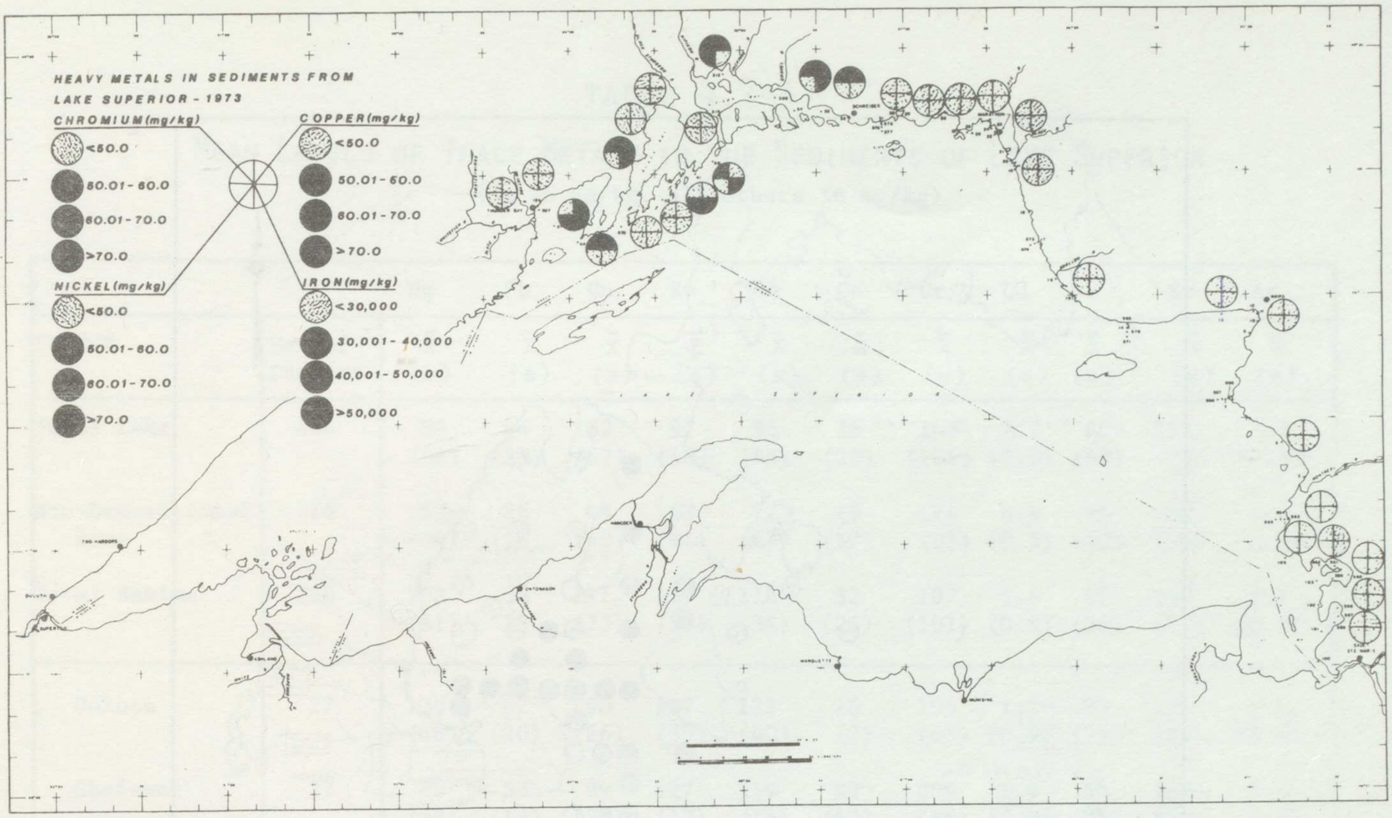


FIG. 4.2-3 Heavy metals distribution in the surficial sediments occurring within the nearshore zone of Lake Superior by sampling locations (Ni, Fe, Cr, Cu).

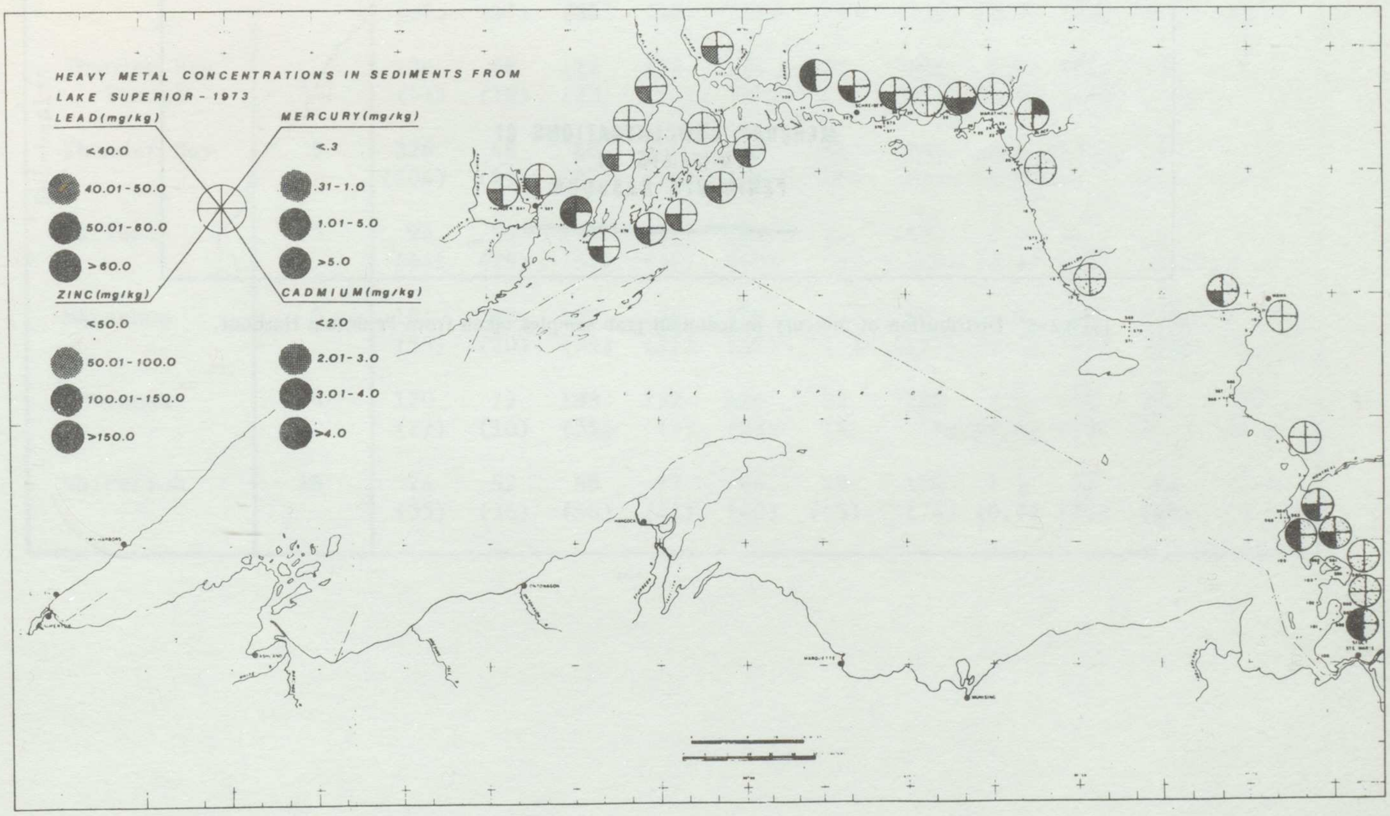


FIG. 4.2-4 Heavy metals distribution in the surficial sediments occurring within the nearshore zone of Lake Superior by sampling locations (Pb, Hg, Zn, Cd).

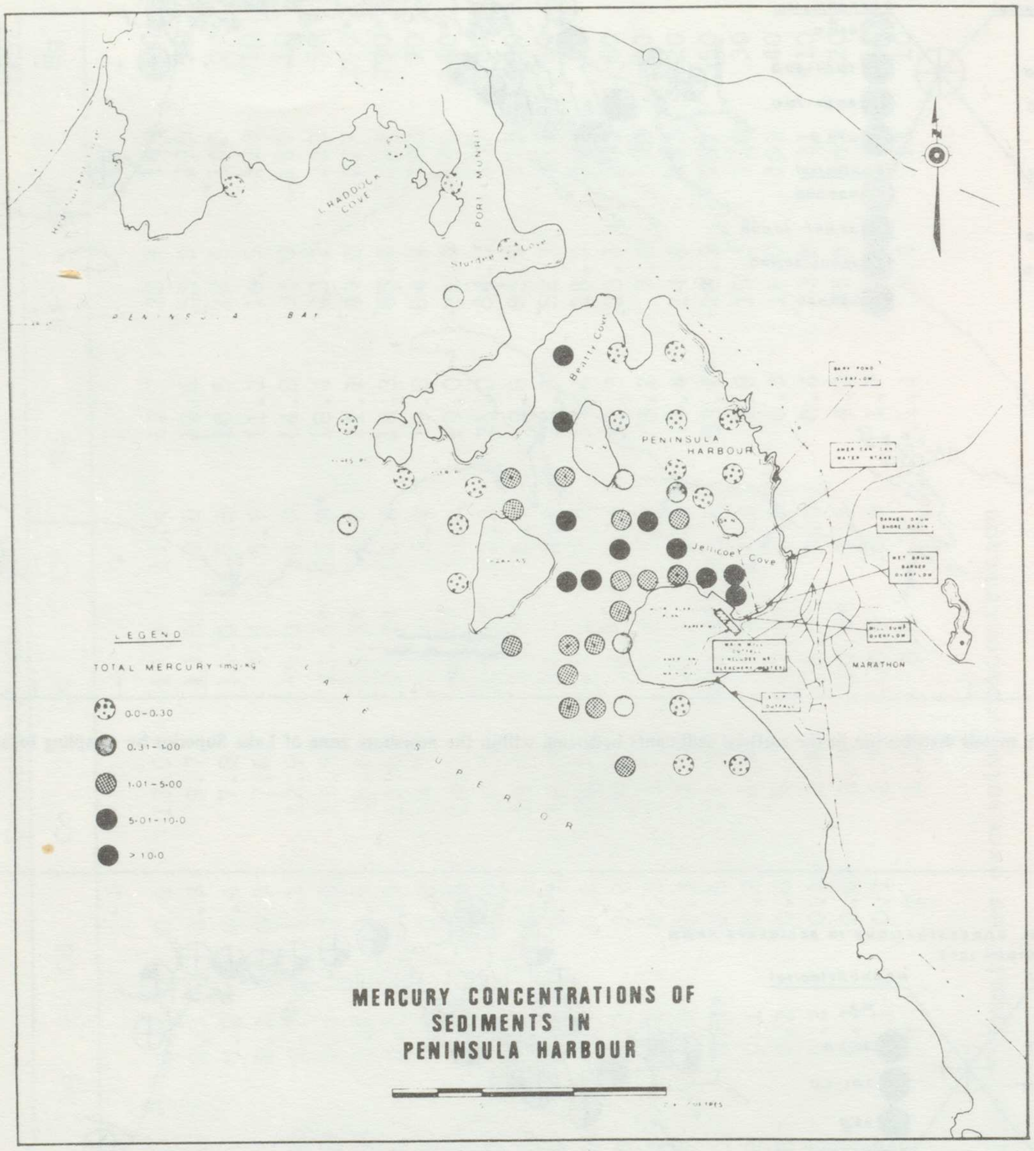


Fig.4.2-5 Distribution of mercury in sediment grab samples taken from Peninsula Harbour.

TABLE 4.2-3

Mean Levels of Trace Metals in the Sediments of Lake Superior

(Hg in μg/kg, all others in mg/kg)

SECTOR	No. of Samples	Hg $\bar{X}$ (s)	Pb $\bar{X}$ (s)	Cu $\bar{X}$ (s)	Zn $\bar{X}$ (s)	Ni $\bar{X}$ (s)	Co $\bar{X}$ (s)	Cr $\bar{X}$ (s)	Cd $\bar{X}$ (s)	V $\bar{X}$ (s)	Sr $\bar{X}$ (s)	As $\bar{X}$ (s)
Total Lake	404	83 (56)	44 (27)	82 (67)	97 (48)	95 (46)	26 (22)	163 (104)	1.2 (0.8)	82 (38)	111 (71)	1.7 (2.5)
Non-Depositional Zone	188	53 (30)	26 (18)	49 (40)	63 (41)	72 (47)	19 (12)	124 (95)	0.8 (0.6)	65 (40)	90 (76)	1.3 (2.2)
Total Basins	216	108 (61)	60 23	111 (73)	127 (33)	116 (34)	32 (26)	197 (101)	1.6 (0.8)	97 (30)	130 (71)	2.1 (2.6)
Sub-basins												
Duluth	27	136 (46)	62 (20)	90 (26)	127 (35)	123 (40)	26 (7)	195 (66)	1.7 (0.5)	93 (33)	139 (24)	2.6 (3.4)
Chefswet	27	86 (23)	53 (16)	99 (28)	127 (17)	119 (15)	42 (63)	209 (36)	1.4 (0.3)	96 (27)	125 (20)	1.5 (1.8)
Apostle	13	112 (25)	56 (15)	177 (247)	143 (16)	122 (22)	34 (4)	218 (45)	1.7 (0.2)	107 (16)	153 (19)	1.7 (2.5)
Isle Royale	50	100 (35)	65 (17)	117 (32)	139 (18)	118 (18)	31 (5)	204 (125)	1.7 (0.3)	111 (17)	140 (24)	2.3 (2.7)
Thunder Bay Trough	17	134 (51)	68 (16)	112 (23)	146 (17)	124 (29)	31 (4)	266 (215)	1.9 (0.4)	102 (19)	138 (20)	4.0 (3.1)
Thunder Bay	5	326 (204)	48 (21)	68 (27)	141 (45)	128 (37)	31 (6)	143 (44)	2.2 (0.8)	128 (24)	175 (84)	3.7 (6.0)
Caribou	49	94 (44)	59 (29)	114 (51)	121 (36)	118 (40)	32 (9)	190 (42)	1.6 (1.4)	94 (29)	120 (38)	1.2 (1.6)
Marathon	6	101 (55)	60 (20)	107 (39)	124 (27)	129 (32)	27 (5)	197 (127)	1.5 (0.4)	96 (22)	118 (26)	3.0 (2.4)
Keweenaw	4	120 (27)	72 (10)	193 (55)	132 (7)	126 (23)	27 (3)	198 (18)	1.5 (0.4)	131 (28)	286 (371)	0.7 (0.9)
Whitefish	18	74 (35)	52 (36)	88 (58)	77 (41)	66 (40)	29 (45)	120 (74)	1.1 (0.7)	52 (26)	61 (28)	1.8 (2.1)

TABLE 4.2-4
1973
HEAVY METALS IN SURFICIAL SEDIMENTS OF LAKE SUPERIOR

Location	Sample Size	PARAMETERS[a,b]							
		Zinc mg/kg	Cadmium mg/kg	Lead mg/kg	Mercury mg/kg	Copper mg/kg	Chromium mg/kg	Nickel mg/kg	Iron %
SEGMENT A	10	54.3±34.4 10.2-105	1.03±0.03 1.00-1.05	24.1±13.4 6.5-47.1	0.033±0.027 0.006-0.072	26.7±17.6 2.8-55.0	26.9±15.0 3.7-45.4	21.0±11.8 2.8-36.2	1.60±0.70 0.42-2.36
SEGMENT B	8	67.2±44.5 27.0-150	<1.00-3.10	<8.0-62.2	0.204±0.388 0.026-1.160	39.7±32.3 8.3-92.0	38.1±16.7 18.9-65.9	29.8±11.9 17.1-49.6	1.77±0.84 0.94-2.10
SEGMENT C	5	84.6±21.4 53.9-109	<1.00	<8.0-30.0	0.047±0.041 0.001-0.089	37.0±11.3 23.3-54.3	45.4±13.2 30.8-65.4	41.9±6.4 34.6-51.0	2.97±0.22 2.73-3.30
PENINSULA HARBOUR	10	49.6±25.7 23.6-98.6	<1.00-3.00	<7.3-25.6	6.10±12.02 0.01-38.50		33.7±12.2 19.8-63.0		
JACKFISH BAY	6	76.6±31.7 48.6-92.6	<1.00	20.4±10.5 13.6-39.6	0.279±0.268 0.027-0.746		53.2±16.1 36.6-73.5		
NIPIGON BAY	2	68.4±44.7 36.8-100	<1.00	<8.0-27.8	0.088±0.036 0.062-0.113	50.5±13.4 41.0-60.0	51.1±17.3 38.9-63.3	45.9±8.9 39.6-52.2	2.66±0.08 2.60-2.72
BLACK BAY	3	62.9±37.9 24.2-100	<1.00-1.65	18.9±13.0 7.3-32.9	0.034±0.015 0.020-0.050	36.3±23.8 10.2-56.8	38.1±18.5 16.8-50.2	33.2±21.5 8.8-49.4	2.14±1.20 0.81-3.13
PINE BAY	4	76.0±14.0 65.6-96.6	2.19±0.51 1.93-2.96	<5.0	0.046±0.040 0.015-0.104	29.2±18.1 16.3-55.2	37.9±5.7 31.5-43.1	33.1±4.1 28.6-37.5	3.11±0.55 2.51-3.83
SEGMENT F	3	15.1±12.9 7.6-30.0	0.97±0.27 0.83-1.3	6.4±4.8 3.6-12.0	0.025±0.022 0.012-0.05	4.5±4.7 1.8-9.9	9.0±8.2 4.3-18.5	8.2±5.9 4.8-15.0	
CHEQUAMEGON BAY	1	62.0	6.0	32.0	0.16	24.0	26.0	20.0	
SEGMENT G	2	30.0±0	1.0±0	10.0±0	0.002±0	8.9±0	23.0±0	15.0±0	
BLACK RIVER	1	8.8	<0.4	3.0	<0.1	2.4	0.4	4.0	0.20
ONTONAGON	6	13.0±6.2 6.4 22.0	<0.4	<1.0-8.0	<0.1	10.6±8.0 5.4-26.0	6.1±3.0 3.2-11.0	10.0±6.2 5.0-20.0	0.34±0.21 0.26-0.62
U. PORTAGE ENTRY	3	19.0±10.1 10.0-30.0	<0.4	3.6±0.5 3.0-4.0	<0.1	154.0±109.5 82.0-280.0	10.5±8.3 4.8-20.0	20.3±15.3 10.0-38.0	0.61±0.46 0.28-1.14
L. PORTAGE ENTRY	3	8.1±1.2 6.8-9.0	<0.4	<1.0-1.0	<0.1	5.9±1.1 4.6-6.6	1.9±0.5 1.8-2.4	2.0±0.0 2.0-2.0	0.18±0.03 0.14-0.20
EAGLE HARBOR	1	14.0	<0.4	<1.0	<0.1	34.0	1.4	13.0	0.38
BIG BAY	1	22.0	<0.4	<1.0	<0.1	4.0	2.6	3.0	0.44
PRESQUE ISLE	6	21.8±13.9 10.0-48.0	<0.4	2.0±0.8 1.0-3.0	<0.1	5.9±6.4 2.6-19.0	9.4±8.4 3.8-26.0	35.5±51.7 6.0-140.0	0.43±0.21 0.30-0.84
CARP RIVER	6	11.1±3.4 6.6-17.0	<0.4	<1.0-3.0	<0.1	2.0±0.6 1.6-3.0	3.0±0.9 2.0-4.0	<1.0-5.0	0.25±0.07 0.17-0.36
MUNISING	6	134±42.5 87.0-190	<0.4	79.5±44.3 44.0-150	0.28±0.13 0.20-0.50	96.6±37.1 51.0-150.0	8.4±5.0 2.4-15.0	28.0±8.9 16.0-38.0	1.20±0.30 0.73-1.50
WHITEFISH POINT	2	16.5±3.5 14.0-19.0	<0.4	4.0±1.4 3.0-5.0	<0.1	6.8±4.5 3.6-10.0	<0.2-0.8	5.0±1.4 4.0-6.0	0.33±0.13 0.24-0.42

a. Key: Mean±Standard Deviation
Minimum Value-Maximum Value

b. If mean and standard deviation are not shown, more than 15% of the results were less than (<) values or sample size = 1.

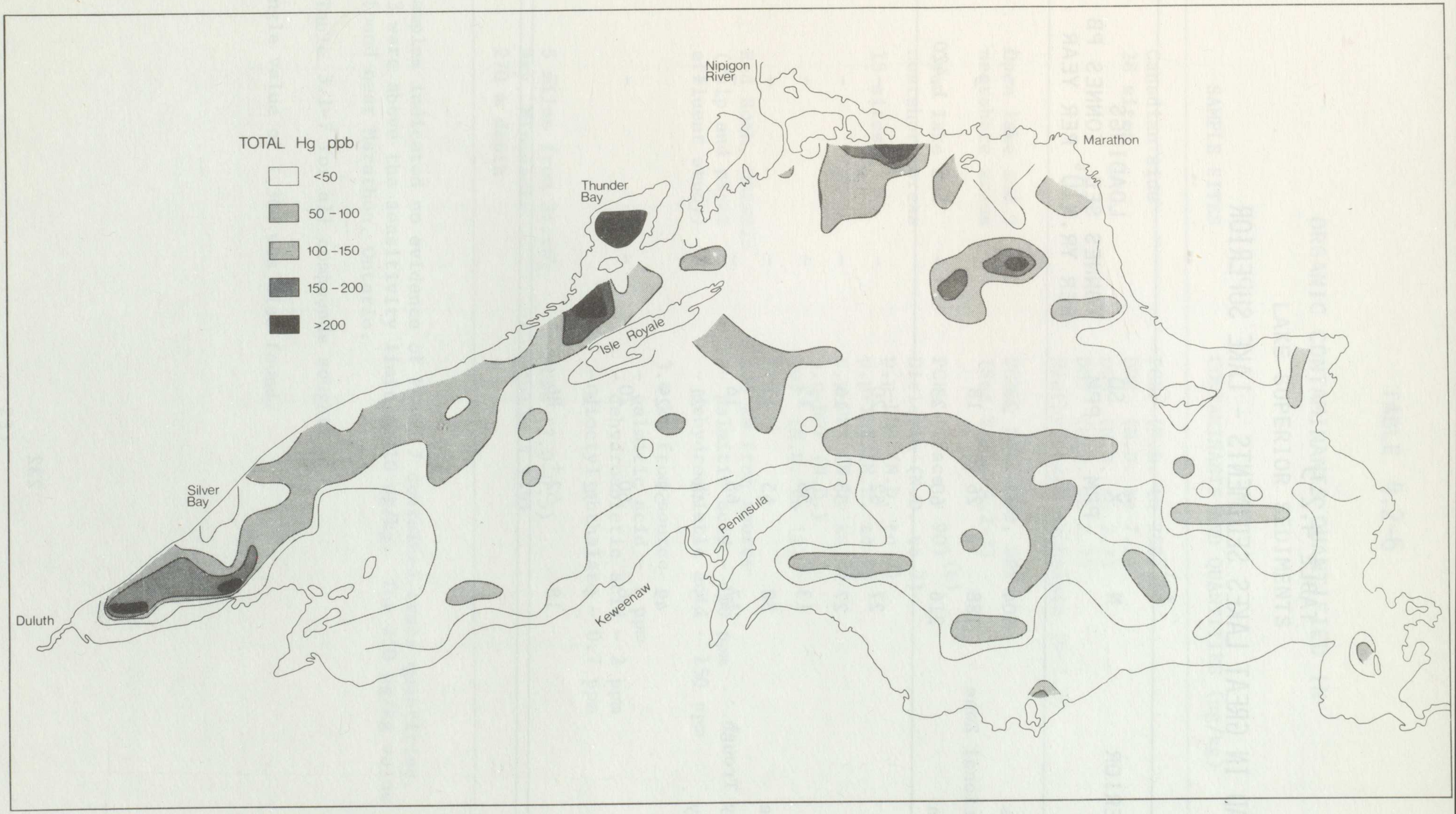


FIGURE 4.2-6. DISTRIBUTION OF MERCURY IN SURFICIAL SEDIMENTS OF LAKE SUPERIOR.

TABLE 4.2-5

LEAD IN GREAT LAKES SEDIMENTS - LAKE SUPERIOR

LAKE SUPERIOR	N	$\bar{X}$ PPM	SD PPM	LOADINGS TONNES SED PER YR. X10^6	TONNES PB PER YEAR
All Samples	404	44	27	-	-
Non Depositional Zone	188	26	18	-	-
Total Basin	216	60	23	-	1,420
Duluth	27	62	20	-	-
Chefswet	27	53	16	-	-
Apostle	13	56	15	-	-
Isle Royale	50	65	17	-	-
Thunder Bay Trough	17	68	16	-	-
Thunder Bay	5	48	21	-	-
Caribou	49	59	29		
Marathon	6	60	20	-	-
Keweenaw	4	72	10		
Whitefish	18	52	86	-	-

TABLE 4.2-6

ORGANIC CONTAMINANTS QUANTIFIED IN LAKE SUPERIOR SEDIMENTS

DATE	SAMPLE SITES	CONTAMINANTS AND QUANTITIES (μg/kg)	Source
1973	Canadian side 28 sites	PCBs (N.D. to 250)[(a)] DDE (N.D. to 7.1) DDD (N.D. to 2.7) DDT (N.D. to 2.7) Diethylhexyl phthalate (0-1.5)	119
1973	Open lake and 5 nearshore areas	PCBs, DDE, DDD, DDT (See Table 4.2-7)	109
1974	Open lake and nearshore areas 15 sites[(b)]	PCBs (Trace - 90)[(c)] Dieldrin (N.D. to 7) p,p-DDE (N.D. to 7) p,p-TDE (N.D. to 5) p,p-DDT (N.D. to 7) o,p-DDT (N.D.) DDT (N.D. to 12)	12
1974	Red Rock, Ontario (Pulp and paper effluent study)	1.0 km from source - palmitic acid - 100 ppm - dehydroabietic acid - 150 ppm 3.0 km from source - palmitic acid - 1 ppm - dehydroabietic acid - 2 ppm - dioctyl phthalate - 0.7 ppm	120
1975	5 miles from Silver Bay, Minnesota 270 m depth	PCBs (7.0 ± 0.5) (Table 4.1-9)	115

(a) 18 samples indicated no evidence of PCBs, 7 contained trace quantities, and 3 were above the sensitivity limit of 10 μg/kg. The 250 μg/kg value was found near Marathon, Ontario.

(b) See Table 3.1-7 for all compounds sought.

(c) A single value of 1,300 was also found.

TABLE 4.2-7

PCB'S AND PESTICIDES IN SEDIMENTS FROM LAKE SUPERIOR

LOCATION			CONCENTRATION IN µg/kg[a]			
	n		PCB	DDE	DDD	DDT
Segment A	10	Min.	b	b	b	b
		Max.	<10	4.2	2.7	1.3
		Mean		1.3		
		Std.Dev.		1.5		
Segment B	8	Min.	b	b	b	b
		Max.	250	3.6	3.2	0.8
		Mean				
		Std.Dev.				
Segment C	5	Min.	b	0.2	0.4	0.5
		Max.	<10	1.0	0.5	1.0
		Mean		0.5	0.5	0.8
		Std.Dev.		0.3	0.1	0.2
Peninsula Harbour	10	Min.	10	c	c	c
		Max.	6500			
		Mean	924			
		Std.Dev.	2000			
Jackfish Bay	6	Min.	b	b	b	b
		Max.	100			
		Mean				
		Std.Dev.				
Nipigon Bay	2	Min.	b	0.9	0.7	1.0
		Max.		3.4	2.3	1.1
		Mean		2.2	1.5	1.1
		Std.Dev.		1.8	1.1	0.1
Black Bay	3	Min.	b	1.0	b	b
		Max.		11.0	4	3
		Mean		6.3		
		Std.Dev.		5.0		
Pine Bay	4	Min.	b	b	b	b
		Max.				
		Mean				
		Std.Dev.				

a. If mean and standard deviation are not shown, then less than (<) values were found for more than 15% of the samples.

b. No detectable concentration

c. No data

4.3 Data on Air Quality and Precipitation

Table 4.3-1 shows the results of studies to evaluate organic contaminant levels in rain and snow in the Lake Superior Basin (46,112). PCB levels in snow samples from Siskiwit Lake in Isle Royale were found to be nearly five times greater than precipitation samples from the Duluth/Superior metropolitan area (112). Because precipitation to the Lake Superior surface accounts for 59% of the lake's water supply, the above studies may indicate the significance of atmospheric inputs as sources of organic contaminants to Lake Superior.

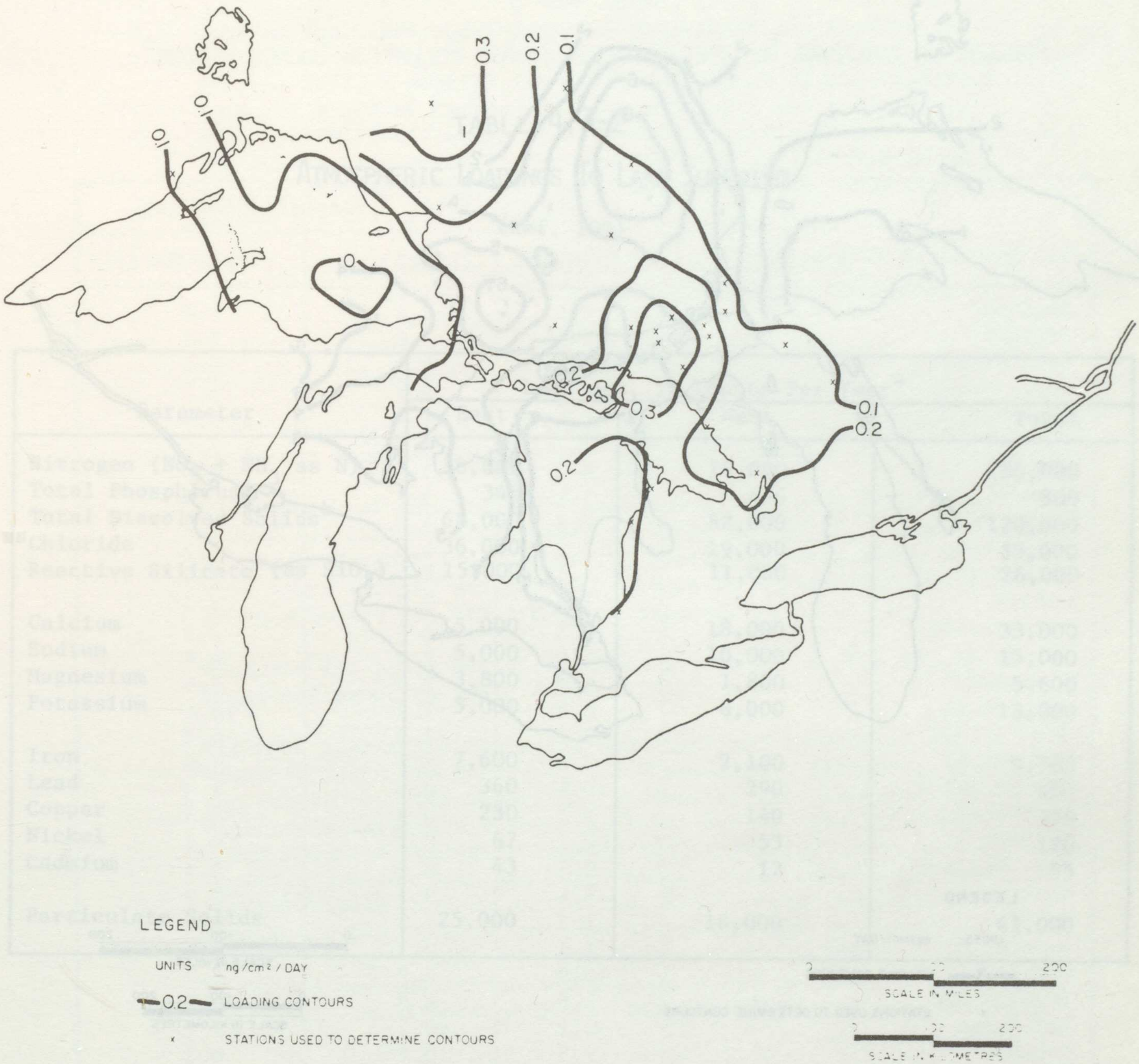
Estimates for yearly deposition of heavy metals to Lake Superior were made by Acres Consulting Services and Applied Earth Science Consultants (101). Figures 4.3-1 and 4.3-2 show the estimated loading contours for cadmium and lead. The quantitative yearly atmospheric loading estimates to Lake Superior, as calculated by the Upper Lakes Reference Group (109) are shown in Table 4.3-2. The estimated percent contributions by various air pollution source regions are given in Table 4.3-3.

As in the case of Lake Huron, the ULRG could not calculate the atmospheric input relative to other sources for toxicants such as mercury, DDT and PCB's, because "most of the input sources sampled were below the detection limit for these materials." Nonetheless, the Reference Group noted that "the present findings indicate significant loadings of many parameters due to long range transport." For example, atmospheric loadings of lead and copper were estimated to be 30-40% of the total input.

TABLE 4.3-1

ANALYSES OF THE ATMOSPHERE AND PRECIPITATION
IN THE LAKE SUPERIOR BASIN

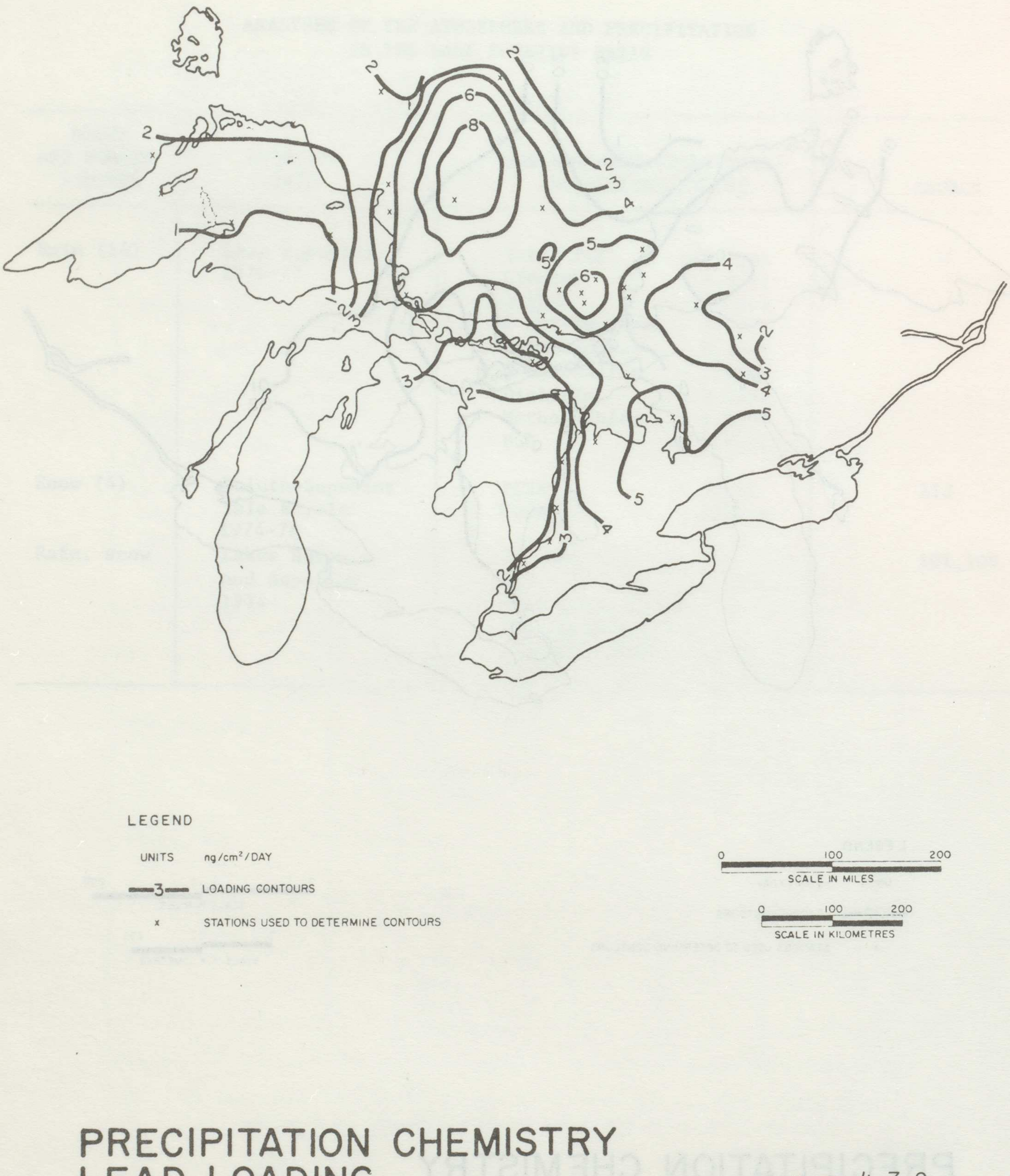
MEDIA AND NUMBER SAMPLES	LOCATION DATE	CONTAMINANTS IDENTIFIED AND CONCENTRATIONS	SOURCE
Rain (14)	Lake Superior 1976-77	Total PCB -26 ppt Lindane - 4.9ppt α BHC - 4.6ppt Σ DDT-Residues - 0.8ppt α Endosulfan - 0.2ppt β Endosulfan - 1.0ppt Dieldrin - 0.5ppt Methoxychlor - 1.6ppt HCB - 2.8ppt	46
Snow (4)	Duluth-Superior Isle Royale 1974-76	PCBs - 50ppt P CBs - 230ppt	112
Rain, snow	Lakes Huron and Superior 1974	Cd, Pb, Ni, Cu (See Table 4.3-2 and Figures 4.3-1 and 4.3-2)	101,109



PRECIPITATION CHEMISTRY
CADMIUM LOADING

FIGURE 4.3-1

ATMOSPHERIC LOADING OF THE UPPER GREAT LAKES



PRECIPITATION CHEMISTRY
LEAD LOADING

FIGURE 4.3-2

ATMOSPHERIC LOADING OF THE UPPER GREAT LAKES

TABLE 4.3-2

ATMOSPHERIC LOADINGS TO LAKE SUPERIOR

(Ref. 109)

Parameter	Loadings, In Tonnes Per Year[a] East	West	Total
Nitrogen (NO_3 + NH_3 as N)	38,000	18,000	56,000
Total Phosphorus	344	456	800
Total Dissolved Solids[b]	68,000	52,000	120,000
Chloride	36,000	19,000	55,000
Reactive Silicate (as SiO_2)	15,000	11,000	26,000
Calcium	15,000	18,000	33,000
Sodium	5,000	10,000	15,000
Magnesium	3,800	1,800	5,600
Potassium	5,000	8,000	13,000
Iron	7,600	2,100	9,700
Lead	360	290	650
Copper	230	140	370
Nickel	67	53	120
Cadmium	43	12	55
Particulate Solids	25,000	16,000	41,000

a. All parameters were determined from actual measurements except for particulate solids values which were calculated from mathematical model results.

b. Calculated from conductivity measurements by multiplying by 0.65.

TABLE 4.3-3

PERCENT OF LOADINGS TO LAKE SUPERIOR BY AIR POLLUTION SOURCE REGION[a]

Air Pollution Source Region[b]	Percent of Total Atmospheric Loading		
	Sulphate	Phosphorus	Trace Metals[c]
Saginaw	4.1	2.1	4.8
Detroit	3.3	3.6	5.5
Port Huron	1.1	0.4	0.5
Lower Michigan	0.8	0.8	1.7
Northern Michigan	2.4	6.1	8.8
St. Louis	7.2	5.2	7.2
Chicago	6.2	13.5	9.8
Central Illinois	5.1	3.7	4.4
Green Bay	2.6	4.5	3.5
Milwaukee	2.3	4.0	3.2
Wisconsin	1.4	5.2	2.4
Duluth	2.2	7.7	3.3
Minneapolis	2.1	2.4	2.5
Toledo	2.0	2.8	4.4
Cleveland	1.8	2.0	2.9
Cincinnati	6.5	7.6	10.4
Ohio	2.1	2.5	4.5
Pittsburgh	3.6	1.1	3.0
Pennsylvania	0.9	0.9	1.9
Rochester	0.1	0.2	0.3
Buffalo	<0.1	0.2	0.2
S.W. New York	0.1	0.1	0.2
Montreal	0.4	3.7	0.9
Toronto	1.2	1.7	0.5
Sarnia	1.1	0.1	0.1
Sudbury	13.0	0.2	0.1
Thunder Bay	2.6	4.3	2.3
Nanticoke	0.2	<0.1	<0.1
Noranda	2.5	0.5	0.3
Sault Ste. Marie	0.6	3.1	4.4
Northern Ontario	19.0	1.6	4.9
Southern Ontario	<0.1	0.5	0.4
Manitoba	1.5	7.7	0.7

a. From Reference 101.

b. United States Environmental Protection Agency and Ontario Ministry of the Environment air pollution source regions.

c. Cd, Cu, Fe, Ni, Pb

4.4 Data on Municipal and Industrial Discharges and Sludges

In June 1977, a special issue of the Journal of the Fisheries Research Board of Canada was published with the title "Pulp and Paper Mill Effluents in a Freshwater Environment." The publication contains the results of a series of studies on pulp and paper mill effluents in Nipigon Bay, Lake Superior, within the following categories:

- i) Effluent dispersion and plume processes
- ii) Ecosystem response and features not necessarily confined to discrete plumes
- iii) Testing of effluent effects upon biota
- iv) Plume oriented biological studies.

Examples of results of effluent analyses reported in the special issue are shown in Table 4.4-1 (116) and Table 4.4-2 (121).

The results of two other effluent scans from wood processing industrial effluents are shown in Table 4.4-3(122). The products of Conwed Corporation are mineral board, tuflex blanket and bulk fibre (wood), and Potlach Forests is a paper manufacturer which utilizes the Kraft pulping process.

Analysis for heavy metals in three discharges to the St. Louis River are shown in Table 4.4-4 (123).

The ULRG identified the major municipal and industrial direct dischargers in its report to the Commission. Estimates from the Reference Group report on loadings by the municipal and direct dischargers are shown in Table 4.4-5. The Reference Group reported that the "largest industrial inputs to Lake Superior are the pulp and paper mills on the Canadian side and Reserve Mining Company on the U.S. side. Large municipal inputs are the Thunder Bay area in Ontario and the Duluth-Superior area in Minnesota and Wisconsin." "In general, the municipal and industrial loading point sources make up a relatively small portion of the total loadings to Lake Superior."

TABLE 4.4-2

COMPOUNDS IDENTIFIED IN DERIVATIZED CHLOROFORM EXTRACTS OF MILL EFFLUENT STREAMS
(Ref. 121)

Compounds	Concentration in Total Effluent µg/L
Dichloroveratrole[(a)]	7
3,4-Dimethoxyacetophenone	6
3,4,5-Trichloroveratrole[(b)]	2.5
Methyl Palmitate	50[(c)]
Ethyl Palmitate	
Methyl Linolenate	60
Methyl Linolelaidate	150
Methyl Stearate	9
Methyl Sandaracopimarate	170
Methyl Isopimarate	380
Methyl Dehydroabietate	1300
Methyl Abietate	1500
Methyl Neoabietate	40
Methyl 9,10-Dihydroxystearate	3
Methyl 7-Ketodehydroabietate[(a)]	25
Dioctyl Phthalate	15

[(a)] Tentative assignment.

[(b)] Structural assignment based on similarity of mass spectrum to published spectrum of 3,4,5-trichloroveratrole.

[(c)] For methyl and ethyl palmitate combined.

TABLE 4.4-3

ORGANIC SCAN OF EFFLUENTS FROM TWO FOREST PRODUCT INDUSTRIES IN MINNESOTA

(Ref. 122)

Parameter (μg/L)	Conwed Corporation, Cloquet, Minnesota, March 2, 1978 — Outfall 001	Outfall 002	Potlatch Forests Inc., Cloquet, Minnesota, March 2, 1978 — Outfall 006 Mill Discharge	Outfall 007 Lagoon Discharge
Dichloro Difluoro Methane	<10.0	<10.0	140.0	20.0
Bromo Dichloro Methane	<10.0	<10.0	40.0	<10.0
Limonene ($C_{10}H_{16}$)	<10.0	<10.0	500.0	130.0
terpinene ($C_{10}H_{16}$)	<10.0	<10.0	140.0	<10.0
Alkyl Benzene ($C_{10}H_{14}$)	<10.0	<10.0	4,000.0	140.0
Trimethyl Bicyclo 3.1.1 Heptene ($C_{10}H_{16}$)	<10.0	<10.0	22,500	180.0
Phenol	<100.0	--	180.0	<100.0
O-Methoxy Phenol	<100.0	--	2,000.0	1,730.0
Benzoic Acid	<100.0	--	845.0	760.0
Linoleic Acid	<100.0	--	7,840.0	<100.0
2-Methyl Pentanoic Acid	<100.0	--	100.0	360.0
Hexanoic Acid	<100.0	--	<100.0	840.0
2-Methyl Phenol	<100.0	--	<100.0	340.0
Tetrachlorophenol	330.0	--	<100.0	<100.0
Pentachlorophenol	2,130.00	--	<100.0	<100.0
T-Butyl Pyrocatechol (1,2 Dihydroxey Benzene	<100	--	1,470.00	<100.0

TABLE 4.4-4

ANALYSES OF MUNICIPAL AND INDUSTRIAL DISCHARGES
TO THE ST. LOUIS RIVER, MINNESOTA

(Ref. 123)

Discharger	Flow MGD	Concentration µg/L Cd	Cr	Cu	Ni	Pb	Zn	Hg
Conwed Corp.								
- outfall 001	.4	12	23	146	<3	33	134	.3
- outfall 002	2.3	2	6	29	<3	18	157	<.1
Potlach Corp.								
- outfall 006	12.6	5	12	31	8	<10	152	.2
- outfall 007	.4	<1	4	15	14	24	62	<.1
Duluth Main Wastewater Treatment Plant	17.5 (average)	<10	120	56	<30	65	260	.3

TABLE 4.4-5

MUNICIPAL AND INDUSTRIAL DIRECT DISCHARGES TO LAKE SUPERIOR

JULY 1973 - JUNE 1975

Parameter	Mean Loading (kg/d)		
	Municipal	Industrial	Total
Alkalinity as $CaCO_3$	4,880	33,600	38,500
Arsenic	0.045	Not Sampled	0.045
Barium	0.421	Not Sampled	0.041
BOD (5 Day @ 20°C)	4,250	196,000	200,000
Cadmium	0.066	9.00	9.07
Calcium	2,270	40,600	42,800
Carbon, Total Organic	Not Sampled	192,000	192,000
Chemical Oxygen Demand	4,840	549,000	554,000
Chloride	3,290	85,900	89,200
Chromium	0.637	1.52	2.16
Copper	3.76	28.1	31.9
Cyanide	4.31	0.500	4.81
Fluoride	25.6	7.95	33.6
Iron	203	655	858
Lead	1.05	9.00	10.1
Magnesium	593	8,620	9,220
Manganese	11.0	335	346
Mercury	0.009	0.340	0.349
Nickel	0.640	30.0	30.6
Nitrogen, Total as N	1,370	1,550	2,920
Nitrogen, Organic as N	575	1,330	1,900
Nitrogen, Ammonia as N	718	89.3	807
Nitrogen, $NO_3 + NO_2$ as N	73.1	140	213
Oil - Grease	158	614	772
Phenols	1.56	218	220
Phosphorus, Total as P	363	271	634
Phosphorus, Reactive PO_4 as P	166	33.6	200
Phthalates	0.025	0.024	0.049
Polychlorinated Biphenyl	0.006	0.005	0.011
Potassium	484	7,740	8,230
Selenium	0.013	Not Sampled	0.013
Silicate, Reactive as SiO_2	655	27,400	28,100
Sodium	2,320	84,200	86,500
Solids, Total	25,200	34,200,000	34,200,000
Solids, Dissolved	21,400	727,000	748,000
Solids, Particulate	3,310	33,400,000	33,400,000
Sulfate as SO_4	1,680	59,400	61,100
Zinc	4.18	175	179

The totals shown above represent all available data. However, some discharges were not sampled for all parameters, and some analytical techniques varied among the four jurisdictions.

4.5 DATA ON BENTHOS AND PLANKTON

PCBs were quantified in 7 of 15 samples of seston from Lake Superior by Glooschenko and Strachan in 1974 (12). The concentrations of the 7 samples varied from 0.5 to 1.3 ppm. Three samples had non-detectable levels and the other five had trace quantities. Seston from the mouths of Black and Thunder Bays near Marathon, Ontario contained from 1.1 to 1.3 ppm PCBs. Trace quantities of dieldrin were found in most samples and 12 of 15 samples contained non-detectable quantities of p,p'-DDE. Veith's data (115) shown in Table 4.1-9 indicates from 0.05 - 0.12 ppm PCBs and 0.04 - 0.05 ppm DDT in Lake Superior zooplankton during 1973-74.

Brownlee and Strachan (121) collected seston from Nipigon Bay at distances up to 6.8 km from the discharge of a Kraft pulp and paper mill. Palmitic acid was detected at concentrations between 150 to 2000 μg/gm dry weight of seston, with no decreasing trend observed at 5.7 km from the source. Dehydroabietic acid varied from 7 to 60 μg/gm, and only trace quantities of dioctyl phthalate were observed.

4.6 DATA ON FISH CONTAMINANTS

Fish contaminant monitoring in Lake Superior is conducted on a routine basis by all jurisdictions within the Lake Superior Basin. For example, the Ontario Fish Contaminant Analysis Program conducted by the Ontario Ministry of Environment and Ontario Ministry of Natural Resources analyzes lake trout and rainbow trout fillets collected from Thunder Bay, Black Bay, Marathon and other nearshore areas. The Minnesota Pollution Control Agency's Water Quality Monitoring Program includes fish contaminant analysis from the St. Louis River and Beaver River. The Water Quality Monitoring Network conducted by the Wisconsin Department of Natural Resources analyzes for mercury and PCBs in selected species from the Nemadji River, St. Louis River and near the city of Ashland. Within the jurisdictional waters of the State of Michigan, the cooperative Great Lakes Environmental Contaminant Survey commonly referred to as "GLECS" (See Section 1.6 for listing of participating agencies) monitors six regional zones (Figure 4.6-1) for contaminant levels in fish that are being utilized by the public to identify levels in excess of recommended maximum U.S. FDA guidelines. As part of the National Pesticide Monitoring Program, the U.S. Fish and Wildlife analyzes whole fish samples during odd years from the nearshore areas of Bayfield, Wisconsin; Keweenaw Point and Whitefish Point, Michigan. Contaminants analyzed include mercury and selected chlorinated hydrocarbons including DDTs, PCBs, chlordane, and other known Great Lakes contaminants.

In addition to the above mentioned ongoing programs, various independent studies have analyzed for contaminants in Lake Superior fish. These programs were performed to address specific questions or research concerns.

Much of the work, such as by Swain (112), and Strachan and Glass (113) was sponsored under the Upper Lakes Reference Group study. Other studies are also summarized in this chapter.

Heavy Metals

The most comprehensive metal analyses in fish from Lake Superior were reported in the Upper Lakes Reference Study (109). Tables 4.6-1 and 4.6-2 show the concentrations (mg/kg wet weight basis) of mercury, copper, zinc, lead and cadmium in fish collected from nearshore waters in 1974. Analyses were performed on fillets. Table 4.6-3 lists the jurisdictions which are undertaking such analyses. Open water whole-fish samples were also analyzed for selected heavy metals. Fish species analyzed were the slimy sculpins (Table 4.6-4), burbot (Table 4.6-5) and lake trout (Table 4.6-6). Table 4.6-7 gives a comparison of whole fish samples versus fillet samples of lake trout from the open waters in the Apostle Islands. Table 4.6-8 gives the concentrations of 42 trace elements detected in whole fish samples of lake trout.

Arsenic, cadmium, chromium, lead and zinc levels in fish from Wisconsin waters for 1970 are presented in Table 4.6-9 as analyzed by the

Wisconsin Department of Natural Resources (125). 1974 data on these and other metals are shown in Table 4.6-10 (126). A summary of other mercury determinations in fish tissues during 1967-68 and 1976 is contained in Table 4.6-11 (56 and 107).

Organic Compounds

As with heavy metals, the most comprehensive organic analysis of fish was that conducted in support of the Upper Lakes Reference Study (Tables 4.6-1 to 4.6-7). Further data on organic compounds in fish fillets from 1974-1976 can be found in Tables 4.6-10, 4.6-12, 4.6-13. Whole fish data obtained during 1974 is shown in Table 4.6-14.

The ULRG studies indicated significant increases in the levels of organic residues in Lake Superior fish near Isle Royale which is a remote island maintained as a National Park. No power generation facilities, mining or timber cutting have ever been permitted. Nor are internal combustion engines allowed. Swain (112) therefore undertook a comprehensive study to determine the possibility of atmospheric precipitation as a source of organic contamination of fish tissue obtained from the Isle Royale area. Subsequently fish from the Lake Superior waters and from the Siskiwit Lake which is located within Isle Royale, were analyzed for approximately 14 organic compounds. The results which are shown in Table 4.6-15 indicate that generally Siskiwit lake trout contain chlorinated hydrocarbons at levels which exceed those observed in Lake Superior lake trout. Swain's results showed the significance of atmospheric transport, and the results of his precipitation analyses are shown in Table 4.3-1.

The ULRG reported a wide range of organic compounds found in Lake Superior lake trout (Table 4.6-16). In its report (109), the Reference Group stated that "Lake Superior is being contaminated with persistent toxic organic compounds from essentially unknown sources." "There is also a real potential that if pollution by toxic organics continues unchecked, the fisheries may eventually be lost because of public health problems or, in the extreme, actual loss of the resource from the lakes. This evidence indicates apparent ineffectiveness of controlling toxic organics through partial bans."

An additional study of interest is by Sills and Allen (106). Efforts were made to quantify the levels of the lampricide TFM in lake trout. However, as seen in Table 4.6-17, no TFM could be detected.

TABLE 4.6-1

CONCENTRATIONS (MG/KG WET WEIGHT BASIS) OF SELECTED TRACE CONTAMINANTS IN FISH COLLECTED FROM NEARSHORE LAKE SUPERIOR WATERS, 1974 MINNESOTA AND ONTARIO[a]

LOCATION	SPECIES	DDT	PCB	DIELDRIN	MERCURY	COPPER	ZINC	LEAD	CADMIUM
MINNESOTA									
Detection Limit					0.001	0.01	0.01	0.05	0.05
Lester River	Sculpin	0.213	0.600	0.028					
French River	Sculpin	0.163	0.300	0.022	0.165	1.14	26.80	0.13	0.09
Stony Cove	Burbot				0.118	0.68	23.60	<0.05	<0.05
	Herring				0.260	1.67	18.50	0.20	0.17
Knife River	Sculpin	0.094	0.050	0.011	0.440	1.18	27.50	0.21	<0.05
Two Harbors	Sculpin	0.051	0.200	0.008	0.041	1.26	34.30	0.43	<0.05
Stewart River	Sculpin	0.036	0.300	0.009	0.061	0.71	43.00	0.09	<0.05
Gooseberry River	Sculpin	0.027	0.200	0.005					
Split Rock River	Sculpin	0.051	0.300	0.012					
Cross River	Burbot				0.046	0.46	15.40	0.09	<0.05
	Sculpin	0.027	0.200	0.015	0.110	0.99	24.15	0.88	<0.05
Cascade River	Sculpin	0.065	0.300	0.013	0.105	1.11	24.10	0.23	0.07
Grand Marais	Brook Trout				0.097	0.28	12.80	<0.05	<0.05
	Sculpin	0.100	0.035	0.006	0.190	0.79	18.75	0.17	<0.05
Grand Portage	Cisco				0.340	0.74	11.10	0.09	0.05
	Herring				0.220	0.77	12.40	0.25	0.07
ONTARIO									
Detection Limit		0.001	0.001	0.001	0.01	0.01	0.01	0.5	0.2
Pine Bay	Lake Trout	0.283	0.512	0.012	0.39	0.69	3.57	<0.5	<0.2
	Walleye	0.104	0.243	0.003	0.60	0.61	3.51	<0.5	<0.2
	Whitefish	0.258	0.279	0.012	0.18	0.63	4.84	<0.5	<0.2
Black Bay	Herring	0.581	0.632	0.014	0.19	0.39	5.19	<0.5	<0.2
	Lake Trout	0.940	1.796	0.048	0.63	0.53	3.21	0.7	0.4
	Whitefish	0.468	0.537	0.043	0.04	0.90	4.01	0.8	<0.2
Nipigon Bay	Herring	0.329	0.757	0.022	0.14	0.59	5.46	<0.5	<0.2
	Lake Trout	0.661	0.765	0.029	0.57	0.20	6.00	<0.5	<0.2
	Whitefish	0.229	0.891	0.012	0.10	0.83	5.68	<0.5	<0.2
Rossport Point	Lake Trout	0.654	0.894	0.016	0.35	0.64	3.58	0.5	<0.2
	Menominee	0.163	0.205	b	0.08	0.51	5.27	0.7	<0.2
	Whitefish	0.303	0.395	0.015	0.20	0.52	3.93	0.5	<0.2
Jackfish Bay	Herring	0.231	0.193	0.008	0.16	0.99	5.39	<0.5	<0.2
	Lake Trout	0.683	0.698	0.036	0.46	0.67	3.63	<0.5	<0.2
	Whitefish	0.084	0.125	0.006	0.06	0.61	4.07	<0.5	<0.2
Marathon	Lake Trout	0.170	0.690	0.011	0.67	0.71	3.39	<0.5	<0.2
	Whitefish	0.382	3.635	0.017	0.76	0.62	4.08	<0.5	<0.2
Michipicoten Bay	Herring	0.480	0.297	0.014	0.25	0.62	5.00	<0.5	<0.2
	Lake Trout	0.383	0.439	0.016	0.47	0.62	3.50	<0.5	<0.2
	Whitefish	0.262	0.240	0.015	0.17	0.61	3.48	<0.5	<0.2
Batchawana Bay	Herring	0.207	0.193	0.010	0.17	0.75	7.02	<0.5	<0.2
	Lake Trout	0.705	0.387	0.023	0.42	0.62	3.49	<0.5	<0.2
	Whitefish	0.229	0.152	0.009	0.13	0.48	3.43	<0.5	<0.2

a. information from references (109)
b. not detected.

TABLE 4.6-2

CONCENTRATIONS (MG/KG WET WEIGHT BASIS) OF SELECTED TRACE CONTAMINANTS IN FISH COLLECTED FROM NEARSHORE LAKE SUPERIOR WATERS, 1974 MICHIGAN AND WISCONSIN[a]

LOCATION	SPECIES	DDT	PCB	DIELDRIN	MERCURY	COPPER	ZINC	LEAD	CADMIUM
MICHIGAN									
Detection Limit		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Whitefish Point	Lake Trout	0.74	0.98	0.03	0.30	0.54	3.80	0.39	0.02
	Fat Lake Trout	1.82	3.18	0.05	0.50	0.35	2.87	0.45	0.02
	Mottled Sculpin	0.23	0.44	0.02	0.04	0.82	11.90	1.50	0.09
Grand Marais	Lake Trout	1.03	1.61	0.02	0.39				
	Mottled Sculpin	0.10	0.29	b	0.03	0.66	11.70	1.40	0.07
Munising	Herring	0.17	0.22	0.01	0.18				
	Lake Trout	3.31	3.31	0.04	0.44				
	Fat Lake Trout	3.46	5.10	0.04	0.71				
	Mottled Sculpin	0.03	0.09	b	0.07				
	Whitefish	0.19	0.27	0.19	0.04				
Marquette	Lake Trout	1.35	1.95	0.02	0.32				
	Fat Lake Trout	3.89	5.05	0.08	0.64				
	Mottled Sculpin	0.06	0.15	b	0.02				
	Whitefish	0.29	0.31	0.02	0.07				
Presque Isle	Mottled Sculpin	0.03	b	b	0.04				
Big Bay	Lake Trout	0.85	1.13	b	0.26				
	Mottled Sculpin	0.09	0.15	0.01	0.05	0.95	12.30	1.20	0.12
Hutch Bay	Mottled Sculpin	b	b	b	0.05	0.75	12.15	1.30	0.10
L'Anse	Mottled Sculpin	b	b	b	0.02	0.66	11.78	1.40	0.08
Lower Portage Entry	Herring	1.18	1.03		0.12				
	Lake Trout	1.35	b	0.02	0.21	0.36	3.11	0.26	0.09
	Mottled Sculpin	0.09	0.04	b	0.02	0.72	11.86	1.20	0.10
Grand Traverse Bay	Mottled Sculpin	0.02	b	b	0.02				
Bete Grise	Whitefish	0.69	0.89	0.08	0.16				
Copper Harbor	Lake Trout	2.44	2.99	0.02	0.36				
	Mottled Sculpin	0.04	0.09	b	0.03	0.90	11.92	1.30	0.11
Eagle Harbor	Mottled Sculpin	0.10	0.15	b	0.02				
Eagle River	Mottled Sculpin	0.43	0.46	0.03	0.04				
Upper Portage Entry	Lake Trout	0.98	1.17	0.02	0.45	0.35	3.34	0.30	0.02
	Mottled Sculpin	b	b	b	0.05	1.22	12.45	1.50	0.13
Carver's Bay	Mottled Sculpin	0.45	0.37	0.03	0.03	0.83	11.81	1.20	0.11
Big Iron River	Mottled Sculpin	0.05	0.09	b	0.03	0.90	12.13	1.40	0.11
Black River	Lake Trout	1.51	2.09	0.03	0.33	0.40	3.44	0.36	0.02
	Fat Lake Trout	5.11	8.37	0.07	0.58	0.29	3.12	0.28	0.04
	Mottled Sculpin	0.62	b	b	0.03				
Isle Royale	Fat Lake Trout	2.10	2.33	b	0.58				
	Mottled Sculpin				0.06	1.30	34.80	0.15	<0.05
Little Girls Point	Lake Trout	0.47	1.25	0.03	0.22	0.56	6.16	0.25	0.02
	Herring				0.61	1.10	22.45	0.39	0.22
	Whitefish				0.06	0.82	8.00	0.23	0.09
WISCONSIN									
Detection Limit		0.001	0.001	0.001	0.01	0.01	0.01	0.02	0.05
Mouth of Bad River	Bullhead	0.011	0.050	·1	0.11	1.10	18.00	<0.02	<0.05
	Northern Pike	0.008	0.020	·1	0.29	0.20	7.00	0.03	<0.05
	Walleye	0.023	0.200	0.004	0.02	0.58	13.00	<0.02	0.06
	White Sucker	0.058	0.024	·1	0.23	0.34	12.00	<0.02	0.08
Kakagon Slough	Bullhead	0.018	0.017	0.002	0.09	0.57	15.00	0.03	0.06
	Northern Pike	0.015	0.030	·1	0.22	0.34	39.00	<0.02	<0.05
	Yellow Perch	0.030	0.050	·1	0.02	0.32	17.00	<0.02	0.05
Chequamegon Bay	Herring	0.057	0.097	·1	0.05	0.29	12.00	0.05	0.05
	Northern Pike	0.025	0.026	·1	0.03	0.24	30.00	<0.02	<0.05
	Smelt	0.173	0.202	0.004	0.08	0.46	21.00	0.02	0.07
	Walleye	0.034	0.110	·1	0.12	0.25	12.00	0.04	<0.05
	Whitefish	0.129	0.202	0.019	0.08	0.40	14.50	0.04	0.07
	Yellow Perch	0.045	0.046	0.003	0.03	0.30	16.60	0.15	0.05
Onion River	Mottled Sculpin				0.04	1.67	28.10	0.07	<0.05
Stockton Island	Mottled Sculpin				0.03	1.23	21.93	0.25	0.05
	Spoonhead Sculpin	0.045	0.300	0.057	0.11	1.28	22.90	0.38	0.09
Bayfield	Lake Trout				0.37	0.73	6.90	<0.05	0.06
Bark Bay	Brook Trout				0.06	0.69	3.80	<0.05	<0.05
Port Wing	Burbot				0.48	0.76	7.13	0.07	<0.05
	Cisco				0.11	0.73	10.20	0.08	<0.05
	Lake Trout				0.15	1.20	12.40	0.09	<0.05
	Long Nose Sucker				0.12	1.40	15.20	0.13	0.09
	Rainbow Trout				0.13	1.05	4.50	0.26	<0.05
	Smelt				0.10	0.69	23.00		
	Sea Lamprey				1.32	2.80	34.90	<0.05	0.05
Mouth of Brule River	Brown Trout	0.193	0.145	0.006	0.12	0.49	6.20	0.04	<0.05
	Rainbow Trout	0.110	0.065	0.002	0.11	1.85	6.10	0.07	<0.05
	Walleye	0.074	0.080	0.005	0.20	0.59	11.03	0.05	0.10
West of Brule River	Rainbow Trout	0.070	0.110	<0.001	0.10	0.36	5.80	0.03	0.02
	Smelt	0.200	0.263	0.007	0.93	0.38	24.30	0.04	0.07
	Walleye	0.229	0.218	0.003	0.38	0.30	8.18	0.03	0.05

a. information from references (109)
b. not detected.

TABLE 4.6-3

CONTAMINANTS MEASURED IN FISH FROM NEARSHORE LAKE SUPERIOR WATERS

	Michigan	Wisconsin	Minnesota	Ontario
Benzene hexachloride		*	*	
Heptachlor-heptachlor epoxide			*	*
Dieldrin	*	*	*	*
Endrin			*	
Aldrin				*
Lindane	*	*	*	*
DDT	*	*	*	*
DDD	*	*	*	*
DDE	*	*	*	*
Chlordane	*	*	*	*
Methoxychlor	*	*		
Mirex			*	
Polychlorinated biphenyl (PCB)	*	*	*	*
Polybrominated biphenyl	*			
Hexachlorobutadiene	*		*	
Hexachlorobenzene	*		*	
Dibutylphthalate	*			
Diethylphthalate			*	
Diethylhexylphthalate	*			
Copper	*	*	*	*
Nickel	*	*	*	*
Lead	*	*	*	*
Zinc	*	*	*	*
Cadmium	*	*	*	*
Manganese				*
Arsenic	*	*	*	*
Chromium	*	*	*	*
Selenium		*	*	*
Mercury	*	*	*	*
Gross α		*		*
Gross β		*		*
Fillet	*	*	*	*
Whole fish	*		*	

TABLE 4.6-4

MEAN CONCENTRATIONS OF TRACE METALS AND ORGANIC CONTAMINANTS (μg/g) AND FAT (%) IN SLIMY SCULPINS (WHOLE FISH) FROM THE OPEN WATERS OF LAKE SUPERIOR[a]

COMPOUND or ELEMENT	GRAND MARAIS	DULUTH	APOSTLE ISLANDS	WHITEFISH POINT	LAKE AVERAGE (UNWEIGHTED)
N[b]	34	50	50	92	
n[c]	2	3	10	10	
Fat	4 (0.50)	4 (0.33)	5 (0.26)	4 (0.22)	4.2
Total PCB	0.36 (0.14)	0.29 (0.05)	0.18 (0.02)	0.16 (0.02)	0.25
Total DDT	0.20 (0.06)	0.17 (0.01)	0.18 (0.02)	0.16 (0.01)	0.18
op' DDT	0.03 (0.01)	0.02 (0.003)	0.02 (0.006)	0.03 (0.005)	0.02
op' DDE	0.01 (0.00)	0.01 (0.00)	0.01 (0.002)	0.01 (0.002)	0.01
pp' DDT	0.05 (0.01)	0.05 (0.009)	0.06 (0.005)	0.04 (0.004)	0.05
pp' DDE	0.08 (0.02)	0.05 (0.003)	0.07 (0.007)	0.06 (0.01)	0.06
pp' DDD	0.04 (0.01)	0.03 (0.003)	0.02 (0.003)	0.02 (0.003)	0.03
Dieldrin	0.02 (0.005)	0.02 (0.003)	0.05 (0.006)	0.05 (0.003)	0.04
Lindane (BHC)			0.01 (0.003)		
Chlordane			0.06 (0.006)		
Methoxychlor			<0.05		
Mercury	0.16 (0.00)	0.05 (0.006)	0.07 (0.004)	0.09 (0.006)	0.09
Arsenic			0.24 (0.007)		
Cadmium			–		
Chromium			–		
Copper			4.59[d] (0.22)		
Lead			–		
Selenium			0.60 (0.01)		
Zinc			21.0[d] (0.36)		

a. The number in parentheses is the standard error of the mean.
b. Number of individual fish.
c. Number of composites analyzed.
d. n = 8

TABLE 4.6-5

MEAN CONCENTRATIONS OF TRACE METALS AND ORGANIC CONTAMINANTS (μg/g) AND FAT (%) IN BURBOT (WHOLE FISH) FROM THE OPEN WATERS OF LAKE SUPERIOR[a]

COMPOUND or ELEMENT	APOSTLE ISLANDS	COPPERMINE BANK	PIC BANK	LAKE AVERAGE (unweighted)
N[b]	50	45	35	
n[c]	10	10	10	
Fat	4 (0.37)	6 (0.23)	5 (0.35)	5.0
Total PCB	1.48 (0.24)	1.40 (0.11)	1.59 (0.24)	1.49
Total DDT	1.51 (0.24)	1.16 (0.10)	1.81 (0.34)	1.49
op' DDT	0.06 (0.007)	0.04 (0.005)	0.09 (0.01)	0.06
op' DDE	0.03 (0.006)	0.02 (0.004)	0.01 (0.001)	0.02
pp' DDT	0.49 (0.07)	0.32 (0.03)	0.52 (0.09)	0.44
pp' DDE	0.75 (0.16)	0.68 (0.07)	1.03 (0.23)	0.82
pp' DDD	0.18 (0.02)	0.10 (0.01)	0.16 (0.02)	0.15
Dieldrin	0.06 (0.004)	0.04 (0.003)	0.05 (0.006)	0.05
Lindane (BHC)	0.06 (0.008)	0.04 (0.01)		0.05
Chlordane	0.17 (0.02)	0.19 (0.008)		0.18
Methoxychlor	<0.05	<0.05		
Mercury	0.48 (0.07)	0.40 (0.02)	0.80 (0.06)	0.56
Arsenic	0.71 (0.04)	0.54 (0.03)		0.62
Cadmium	0.03 (0.002)	0.03 (0.002)		0.03
Chromium	0.06 (0.003)	0.07 (0.004)		0.06
Copper	1.52 (0.06)	1.61 (0.02)		1.56
Lead	0.04 (0.004)	0.05 (0.002)		0.04
Selenium	0.51 (0.01)	0.65 (0.01)		0.58
Zinc	13.9 (0.20)	12.9 (0.23)		13.4

a. The number in parentheses is the standard error of the mean.
b. Number of individual fish.
c. Number of composites analyzed.

TABLE 4.6-6

MEAN CONCENTRATIONS OF TRACE METALS AND ORGANIC CONTAMINANTS (μg/g) AND FAT (%) IN LAKE TROUT (WHOLE FISH) FROM THE OPEN WATERS OF LAKE SUPERIOR[a]

COMPOUND or ELEMENT	GRAND MARAIS	DULUTH	APOSTLE ISLANDS	KEWEENAW POINT	WHITEFISH POINT	COPPERMINE BANK	CHUMMY BANK	PIC BANK	BATEAU ROCK	LAKE AVERAGE (unweighted)
N[b]	12	41	46	50	30	49	50	50	50	
n[c]	10	10	10	10	10	10	10	10	10	
Fat	20 (1.84)	16 (0.78)	15 (0.60)	31 (1.13)	17 (1.11)	26 (1.15)	18 (0.67)	21 (0.61)	16 (0.78)	20.0
Total PCB	1.72 (0.22)	1.85 (0.09)	1.80 (0.22)	4.32 (0.27)	0.80 (0.07)	2.27 (0.26)	1.15 (0.13)	2.67 (0.25)	1.65 (0.14)	2.02
Total DDT	1.82 (0.35)	1.64 (0.14)	6.29 (0.76)	7.08 (0.59)	1.12 (0.11)	8.17 (0.70)	1.27 (0.15)	3.99 (0.61)	8.06 (0.89)	4.38
op' DDT	0.14 (0.02)	0.17 (0.02)	0.62 (0.07)	0.40 (0.03)	0.12 (0.01)	0.41 (0.04)	0.11 (0.02)	0.30 (0.03)	0.53 (0.08)	0.31
op' DDE	0.02 (0.003)	0.03 (0.004)	0.34 (0.04)	0.06 (0.01)	0.04 (0.004)	0.10 (0.01)	0.10 (0.01)	0.03 (0.02)	0.19 (0.02)	0.10
pp' DDT	0.42 (0.10)	0.31 (0.03)	1.25 (0.21)	1.77 (0.15)	0.25 (0.03)	2.21 (0.14)	0.30 (0.04)	1.00 (0.19)	1.93 (0.29)	1.04
pp' DDE	1.07 (0.20)	0.97 (0.09)	3.28 (0.48)	4.38 (0.38)	0.63 (0.07)	5.15 (0.49)	0.68 (0.07)	2.43 (0.36)	4.64 (0.44)	2.58
pp' DDD	0.17 (0.03)	0.16 (0.01)	0.80 (0.05)	0.47 (0.05)	0.08 (0.007)	0.39 (0.04)	0.08 (0.01)	0.23 (0.03)	0.77 (0.14)	0.35
Dieldrin	0.06 (0.008)	0.08 (0.006)	0.47 (0.04)	0.12 (0.02)	0.06 (0.003)	0.10 (0.01)	0.06 (0.006)	0.08 (0.006)	0.32 (0.03)	0.15
Lindane (BHC)			0.05 (0.008)			0.20 (0.01)				0.12
Chlordane			0.54 (0.08)			0.59 (0.05)				0.56
Methoxychlor			<0.05			<0.05				
Mercury	0.52 (0.08)	0.40 (0.02)	0.39 (0.02)	0.88 (0.03)	0.27 (0.02)	0.78 (0.03)	0.26 (0.02)	0.58 (0.04)	0.50 (0.04)	0.51
Arsenic			0.41 (0.02)			0.61 (0.02)				0.51
Cadmium			0.01 (0.001)			0.02 (0.001)				0.02
Chromium			0.05 (0.005)			0.04 (0.004)				0.04
Copper			0.75 (0.04)			0.90 (0.05)				0.82
Lead			0.05 (0.005)			0.03 (0.003)				0.04
Selenium			0.40 (0.02)			0.54 (0.02)				0.47
Zinc			12.9 (0.31)			11.4 (0.40)				12.2

a. The number in parentheses is the standard error of the mean.
b. Number of individual fish.
c. Number of composites analyzed.

TABLE 4.6-7

MEAN CONCENTRATIONS OF TRACE METALS AND ORGANIC CONTAMINANTS (µg/g) AND FAT (%) IN LAKE TROUT (WHOLE FISH AND FILLETS) FROM THE OPEN WATERS IN THE APOSTLE ISLANDS, LAKE SUPERIOR[a]

COMPOUND or ELEMENT	WHOLE LAKE TROUT	LAKE TROUT FILLET
N[b]	46	49
n[c]	10	10
Fat	15 (0.60)	9 (0.38)
Total PCB	1.80 (0.22)	1.68 (0.15)
Total DDT	6.29 (0.76)	2.99 (0.31)
op' DDT	0.62 (0.07)	0.31 (0.03)
op' DDE	0.34 (0.04)	0.14 (0.01)
pp' DDT	1.25 (0.21)	0.67 (0.08)
pp' DDE	3.28 (0.48)	1.50 (0.20)
pp' DDD	0.80 (0.05)	0.37 (0.03)
Dieldrin	0.47 (0.04)	0.21 (0.02)
Lindane (BHC)	0.05 (0.008)	0.03 (0.006)
Chlordane	0.54 (0.08)	0.22 (0.02)
Methoxychlor	<0.05	<0.05
Mercury	0.39 (0.02)	0.51 (0.04)
Arsenic	0.41 (0.02)	0.33 (0.02)
Cadmium	0.01 (0.001)	0.002 (<0.001)
Chromium	0.05 (0.005)	0.07 (0.002)
Copper	0.75 (0.04)	0.46 (0.02)
Lead	0.05 (0.005)	0.012 (0.002)
Selenium	0.40 (0.02)	0.41 (0.01)
Zinc	12.9 (0.31)	3.61 (0.09)

a. The number in parentheses is the standard error of the mean.

b. Number of individual fish.

c. Number of composites analyzed.

TABLE 4.6-8

TRACE ELEMENTS DETECTED BY SPARK SOURCE MASS SPECTROMETRY IN WHOLE-FISH SAMPLES OF LAKE TROUT FROM THE OPEN WATERS OF LAKE SUPERIOR. CONCENTRATIONS IN µG/G

ELEMENT	COPPERMINE BANK	APOSTLE ISLANDS
Lead (Pb)	0.10	0.11
Neodymium (Nd)	–	0.035
Praseodymium (Pr)	–	–
Cerium (Ce)	–	0.005
Lanthanum (La)	–	0.13
Barium (Ba)	0.055	0.12
Cesium (Cs)	0.010	0.020
Iodine (I)	16	25
Tellurium (Te)	–	0.010
Tin (Sn)	7	0.43
Indium (In)	0.030	0.13
Cadmium (Cd)	–	–
Silver (As)	0.045	0.18
Rhodium (Rh)	–	0.020
Molybdenum (Mo)	0.025	0.22
Zirconium (Zr)	–	–
Strontium (Sr)	1.2	2.3
Rubidium (Rb)	2.8	3.8
Bromine (Br)	3.1	8.2
Selenium (Se)	0.18	0.20
Arsenic (Ar)	0.002	0.005
Germanium (Ge)	0.24	0.27
Gallium (Ga)	0.015	0.005
Zinc (Zn)	21	27
Copper (Cu)	–	–
Nickel (Ni)	–	–
Cobalt (Co)	0.36	0.37
Iron (Fe)	14	12
Manganese (Mn)	2.7	3.7
Chromium (Cr)	1.6	0.98
Vanadium (V)	0.085	0.085
Titanium (Ti)	0.16	0.20
Scandium (Sc)	0.055	0.12
Aluminum (Al)	–	–
Fluorine (F)	0.020	0.46
Calcium (Ca)	>45	>71
Potassium (K)	>16	>16
Chlorine (Cl)	> 5	>53
Sulphur (S)	>23	>22
Phosphorus (P)	>26	>38
Magnesium (Mg)	> 7	>82
Sodium (Na)	>24	>32

TABLE 4.6-9

(Ref. 125)

Arsenic, Cadmium, Chromium, Lead and Zinc Levels in Fish From Wisconsin Waters

Water	County	Site	Date	Sample Number	Species	Length (Inches)	Metal Levels in ppm Cr	Zn	Cd	As	Pb
Brule River	Douglas	T49N, R10W, S10	21 Jul 1970	464	Sucker	15.0			0		0.27
				463	Sucker	16.0	0	4.3		0	–
				450	6 Sucker	10.0		–	0		0
				461	Walleye	13.0	0	3.7		0.13	–
				459	Walleye	13.0			0	–	0
				456	Brown Trout	10.0			0	–	0.30
				448	Brown Trout	10.2	0.08	5.7			
				454	2 Rainbow Trout	8.0-10.0	0	4.0		0	–
Lake Superior	Bayfield	Apostle Island	12 Aug 1970	778	Sucker	14.0	–	–	0	–	0.25
				777	Sucker	16.2	–	–	0	–	0.21
				776	Sucker	18.8	0.20	4.0	–	0.12	–
				772	Brown Trout	17.7	–	–	0	–	0.21
				771	Brown Trout	17.7	0.09	4.2	–	0	–
				782	Lake Trout	20.6	–	–	0	–	0.34
				781	Lake Trout	20.7	0.07	3.4	–	0.12	–
St. Croix River	Douglas	Gordon and St. Croix Flowage	20 Oct 1970	1,448	White Sucker	12.5					0.25
				1,447	White Sucker	17.5					0.76
				1,480	2 Crappie	8.0-9.0	0.10	14.2		0.10	
				1,475	7 Pumpkinseed	4.5-6.2	0.08	17.0		0.17	
				1,466	Largemouth Bass	15.0					0.25
				1,464	Largemouth Bass	18.0	0.05	3.5		0.10	
				1,457	Northern Pike	16.0	0.05	5.1		0.10	
				1,453	Northern Pike	24.0					0.58
				1,452	Northern Pike	28.0					0.36
St. Louis River	Douglas	River Mouth	5 May 1970 and 11 Aug 1970	834	Sucker	13.5			0		0.33
				833	Sucker	14.0			0		0.45
				832	Sucker	14.0	0.06	3.5		0.10	
				831	Sucker	16.5	0.05	3.8		0	
				164	Walleye	22.5			0		0.05
				162	Walleye	23.7	0.04	3.9		0.10	

TABLE 4.6-10

RESULTS OF ANALYSES OF FISH BY THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Location	Species & Size	Sample No.	Lab No.	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	^{40}K [1]	^{137}Cs [1]	Gross Beta	Alpha	DDE	DDD	DDT	Dieldrin	Chlordane	BHC	Methoxychlor	Fat %	PCB	Date
				Metals – mg/kg									*Radioactivity – pCi/g*				*Pesticides and PCBs – ug/kg*									
3 mi. west of Brule River	Smelt 5.7"–10"	1	57347	.33	.056	.10	.30	.08	<.1	<.02	.37	23	2.7–.6	.22–.05	3.1–.2	<.12	159	20	66	3.9	10	< 1	< 2	4.2	270	8/07/74
"	Smelt 5.7"–10"	2	57348	.25	.092	.11	.42	.08	<.1	.06	.38	24	3.0–.4	.31–.04	3.1–.2	<.14	143	20	54	10.5	10	< 1	< 2	4.3	250	"
"	Smelt 5.7"–10"	3	57349	.38	.062	.22	.42	.12	<.1	.06	.40	26	2.2–.2	.20–.02	2.9–.2	<.14	100	12	26	< 1	50	<1	< 2	4.5	270	"
"	Walleye 21.0"	4	57350	.14	.029	.06	.28	.39	<.1	<.02	.52	6.2	3.0–.2	1.59–.02	5.3–.4	<.13	400	38	225	4.65	50	< 1	< 2	1.3	315	"
"	Walleye 19.5"	5	57351	.10	.022	.06	.50	.54	<.1	.10	.50	5.7	3.4–.6	1.24–.06	4.8–.3	<.08	87	17	59	2.4	10	< 1	< 2	.6	160	"
"	Walleye 19.8"	6	57352	.26	.051	.07	.24	.48	<.1	<.02	.42	5.3	2.9–.4	1.38–.04	5.0–.4	.14–.03	69	12	40	3.6	20	< 1	< 2	1.35	150	"
"	Walleye 18.0"	7	57353	.04	.052	.08	.34	.42	<.1	<.02	.44	10.0	3.3–.6	1.17–.06	4.5–.3	<.14	105	20	75	0.5	50	< 0.5	< 2	1.43	315	"
"	Walleye 19.0"	8	57354	.07	.054	.05	.15	.36	<.1	<.02	.52	6.9	2.9–.6	1.17–.06	4.6–.3	<.10	75	12	45	<1	40	< 1	< 2	1.48	150	"
"	Walleye 9.0"–10.3"	9	57355	.03	.087	.08	.27	.10	<.1	.04	.29	15.0	2.7–.6	.55–.06	4.3–.3	<.17	41	18	40	4.1	50	< 1	< 2	1.22	150	"
"	Rainbow Trout 22.5"	15	57361	.15	.024	.09	.36	.10	<.1	.03	.52	5.8	3.5–.6	.77–.06	4.6–.5	<.09	60	3	6.5	0.5	Int.	< 0.5	< 1	2.70	110	"
Mouth of Brule River	Walleye 8.2"–9.5"	10	57356	.13	.044	.07	.95	.14	<.1	.05	.36	15.0	3.0–.6	.71–.06	4.5–.3	<.22	53	15	42	0.5	10	< 1	< 2	1.25	120	7/17/74
"	Walleye 11.5"–17.8"	11	57357	.10	.23	.06	.50	.22	<.1	.06	.42	7.1	3.3–.6	.95–.06	5.5–.4	<.15	19	6.5	16	2	10	< 1	< 2	.68	55	"
"	Walleye 10.0", 11.5" and 13.0"	12	57358	.07	.027	.09	.33	.24	<.1	.03	.40	11.0	3.1–.6	.65–.06	4.0–.3	<.16	34	10	29	11	50	< 1	< 2	.97	66	"
"	Rainbow Trout 27.2"	13	57359	.03	.017	.07	3.4	.09	.4	.07	.82	7.5	4.0–.6	.83–.06	4.7–.3	<.09	53	8	6	3.6	10	< 1	< 2	1.18	40	9/13/74
"	Rainbow Trout 27.4"	14	57360	.03	.020	.04	.29	.13	<.1	.07	.79	4.7	3.1–.6	.72–.06	4.2–.3	.28–.06	105	27	20	<1	50	< 1	< 2	2.49	90	"
"	Brown Trout 20.3"	16	57362	.15	.014	.04	.50	.135	<.1	.04	.56	4.8	4.3–.6	.57–.06	4.4–.3	<.07	110	16	50	10	50	< 1	< 2	4.04	215	"
"	Brown Trout 19.2"	17	57363	.10	.022	.05	.50	.16	<.1	.08	.44	5.7	3.4–.6	.53–.06	4.6–.5	<.08	93	16	32	1.5	50	< 1	< 2	5.26	235	"
"	Brown Trout 21.1"	18	57364	.17	.010	.14	.46	.09	<.1	<.02	.57	8.1	3.6–.6	.66–.06	4.7–.5	<.09	58	13	48	6.6	50	< 1	< 2	4.42	130	"
Mouth of Bad River	Northern Pike 19.1"–20.5"	19	57365	.03	.026	.06	.20	.29	<.1	.03	.31	7.0	3.5–.6	.21–.06	3.8–.3	<.10	4.5	1	2	<1	10	< 0.5	< 2	.11	20	3/13/74
"	Bullheads 4.7", 6.4", 7.1" & 9.9"	20	57366	.03	.022	.12	1.1	.11	<.1	<.02	.22	18.0	2.7–.6	< .15	3.4–.3	<.22	5.8	2	3	<1	10	< 2	< 2	2.80	50	"

TABLE 4.6-10 CONT'D

Location	Species & Size	Sample No.	Lab No.	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	^{40}K[1]	^{137}Cs[1]	Gross Beta	Alpha	DDE	DDD	DDT	Diel-drin	Chlor-dane	BHC	Methoxy-chlor	Fat %	PCB	Date
				Metals – mg/kg									Radioactivity – pCi/g				Pesticides and PCBs – ug/kg									
Mouth of Bad River (Cont.)	Walleyes 9.3", 9.9" 11.0" & 11.2"	21	57367	.12	.062	.08	.58	.02	<.1	<.02	.46	13.0	3.3–.2	.35–.02	4.4–.4	<.23	16	2	5	3.5	50	<0.5	<2	1.83	200	9/13/74
"	White Sucker 16.9"	22	57368	.10	.081	.12	.34	.23	<.1	<.02	.39	12.0	2.4–.6	.17–.06	3.7–.3	<.22	36	6	10	<1	20	<1	<2	1.48	24	"
Chequamegon Bay	Perch 10"	39	57385	.03	.040	.08	.30	.03	<.1	<.02	.40	13.0	3.3–.6	.23–.06	3.3–.2	<.20	52	8	21	9	20	<1	<2	N.A.	97	8/16/74
"	Perch (5) 7" to 8"	30	57376	.04	.093	.08	.34	.05	<.1	.63	.54	18.0	2.8–.5	.28–.06	4.8–.3	<.36	40	2	4	<1	20	<1	<2	1.48	20	"
"	Perch (5) 7" to 8"	31	57377	.03	.028	.11	.36	.02	.2	<.02	.50	20.0	2.7–.5	.23–.06	3.8–.4	<.30	23	4	10	3.8	40	<1	<2	1.72	45	"
"	Perch (5) 7" to 8"	32	57378	.03	.048	.22	.27	.05	<.1	.04	.51	16.0	2.8–.3	.21–.03	4.5–.3	<.35	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	"
	Perch (5) 7" to 8"	33	57379	.03	.038	.09	.21	.03	<.1	.04	.38	16.0	2.5–.5	.19–.06	3.8–.3	<.35	10	2	4	<1	20	<1	<2	1.51	20	"
"	Smelt (10) 6" to 10"	34	57380	.10	.084	.09	.49	.09	<.1	.04	.42	22.0	2.1–.4	.24–.06	3.5–.2	<.14	105	16	57	<1	50	<2	<2	N.A.	245	"
"	Smelt (10) 6" to 10"	35	57381	.03	.081	.05	.34	.045	<.1	<.02	.49	18.0	3.0–.2	.22–.02	3.5–.4	.43–.09	73	10	35	2	20	<1	<2	5.65	150	"
"	Smelt (10) 6" to 10"	36	57382	.14	.056	.10	.55	.11	<.1	<.02	.49	23.0	3.1–.6	.20–.06	3.7–.4	<.13	150	17	56	10	20	<1	<2	4.10	210	"
"	Whitefish (4) 6" to 11"	37	57383	.18	.065	.11	.38	.07	<.1	.03	.48	17.0	3.4–.6	.16–.06	4.3–.3	<.15	58	10	43	7.5	20	<1	<2	2.90	94	"
"	Whitefish 17.0"	38	57384	.17	.059	.06	.42	.08	<.1	.04	.41	12.0	2.9–.5	.36–.06	4.3–.4	.13–.03	90	16	40	31	50	<5	< 10	10.30	310	"
"	Walleye 10" to 13"	40	57386	.03	.046	.11	.25	.12	<.1	.04	.41	12.0	3.4–.6	.45–.06	4.2–.4	<.22	18	5	11	<1	50	<1	<2	N.A.	110	"
"	Lake Herring 9" to 15"	23	57369	.19	.050	.11	.29	.05	<.1	.05	.64	12.0	2.7–.6	<.15	4.3–.4	<.20	35	6	16	<1	Int.	<5	<2	3.68	97	"
"	Northern Pike 13"	41	57387	.05	.026	.05	.24	.03	<.1	<.02	.28	30.0	3.2–.6	.17–.06	3.7–.3	<.18	17	3	5	<1	20	<1	<2	N.A.	26	"
Kakagon Slough	Perch 5.0"	24	57370	.18	.062	.08	.31	.01	<.1	<.02	.40	18.0	3.9–.6	.17–.06	3.9–.4	<.30	30	3.5	8	<1	40	<1	<2	N.A.	66	8/16 74
"	Northern Pike 18.0"	25	57371	.03	.039	.07	.34	.22	<.1	<.02	.17	39.0	2.4–.6	.22–.06	3.9–.4	<.21	8.5	2	4	<1	20	<1	<2	.54	30	"
"	Perch (3) 5" to 8"	26	57372	.11	.034	.06	.32	.02	<.1	<.02	.15	16.0	2.9–.6	.22–.06	3.7–.3	<.25	12	2	4	<1	20	<1	<2	–	33	9/17/74
"	Bullheads 5" to 8"	27	57373	.05	.031	.08	.51	.06	<.1	.05	.27	15.0	2.9–.6	<.15	3.3–.3	<.24	12.7	2	4	3.2	10	<1	<2	3.46	16.7	"
"	Bullheads (10) 5" to 8"	28	57374	.19	.092	.06	.61	.14	<.1	.04	.19	15.0	2.1–.4	.16–.06	3.2–.3	<.22	10	5	5	<1	20	<1	<2	4.22	30	"
"	Bullheads (10) 5" to 8"	29	57375	.10	.045	.08	.58	.08	<.1	<.02	.17	15.0	2.3–.4	<.15	3.8–.3	<.18	11	1	2	3.4	10	<1	<2	3.75	3	"

TABLE 4.6-10 CONT'D

				Metals – mg/kg									Radioactivity – pCi/g				Pesticides and PCBs – ug/kg									
Location	Species & Size	Sample No.	Lab No.	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	^{40}K [1]	^{137}Cs [1]	Gross Beta	Alpha	DDE	DDD	DDT	Dieldrin	Chlordane	BHC	Methoxychlor	Fat %	PCB	Date
Mouth of the Nemadji River	Carp 24.0"	42	57388	.08	.018	.04	.30	.11	<.1	.04	.27	20.0	2.6–.5	<.15	3.5–.3	<.10	20	33	15	<1	Int.	<1	< 2	5.10	280	7/11/74
"	Carp 24.0"	43	57389	.03	.013	.06	.17	.115	<.1	<.02	.37	20.0	3.3–.6	<.15	3.7–.4	<.10	16	58	20	<1	Int.	<1	< 2	6.61	335	"
"	Carp 26.5"	44	57390	.07	.018	.08	.25	.12	<.1	<.02	.43	15.0	2.1–.4	<.15	3.4–.2	<.11	138	360	50	<1	Int.	<1	< 2	11.0	1340	"
"	Carp 27.5"	45	57391	.04	.029	.05	.32	.17	<.1	.04	.28	12.0	3.1–.6	<.15	3.7–.3	<.10	58	175	60	<1	Int.	<1	< 4	6.87	650	"
"	Carp 27.8"	46	57392	.14	.021	.08	.19	.19	<.1	.04	.31	18.0	1.7–.4	<.15	3.0–.2	<.09	80	190	10	<1	Int.	<1	< 2	7.97	1140	"
"	Carp 25.0"	47	57393	.07	.021	.06	.22	.13	<.1	<.02	.36	16.0	3.3–.6	<.15	3.5–.3	<.10	13	42	22	3.4	50	<0.5	< 2	2.80	260	"
"	Northern Pike 26.9"	48	57394	.03	.020	.11	.30	.21	<.1	<.02	.31	36.0	3.2–.6	.38–.06	4.3–.4	<.12	235	60	115	<1	Int.	<1	< 2	2.90	650	"
"	Northern Pike 22.2"	49	57395	.04	.045	.09	.21	.11	<.1	<.02	.35	19.0	2.9–.2	.32–.02	4.0–.3	<.16	120	23	50	<1	50	<1	< 2	2.11	240	"
"	Northern Pike 17.8"	50	57396	.03	.031	.06	.15	.28	<.1	<.02	.32	17.0	3.2–.6	.30–.06	3.9–.3	<.20	50	19	32	<1	50	<1	< 2	1.13	120	"
"	Northern Pike 15.8"	51	57397	.10	.046	.05	.21	.19	<.1	<.02	.24	20.0	2.9–.5	<.15	3.7–.3	<.22	17	10	14	<1	50	<1	< 2	.51	50	"
"	Walleye (2) 14.0"	52	57398	.29	.052	.06	.21	.16	<.1	<.02	.39	11.0	3.2–.2	.43–.02	4.5–.5	<.23	65	47	75	6.5	50	<1	< 2	1.32	355	"
"	Walleye (3) 10" to 12"	53	57399	.10	.017	.09	.24	.14	<.1	<.02	.39	12.0	3.3–.6	.33–.06	4.7–.5	<.22	26	16	25	<1	50	<1	< 2	1.19	285	"
"	Walleye (5) 8" to 10"	54	57400	.11	.019	.04	.24	.08	<.1	<.02	.28	13.0	3.7–.6	.46–.06	4.9–.5	<.24	23	20	35	2	40	<1	< 2	1.22	174	"
"	Perch (3) 7" to 9"	55	57401	.05	.017	.06	.65	.11	<.1	<.02	.39	9.0	2.6–.3	<.15	4.1–.3	<.31	26	60	58	<1	Int.	<1	< 2	2.30	440	"
"	Perch (3) 7" to 9"	56	57402	.09	.026	.10	.27	.07	.2	<.02	.30	16.0	3.2–.6	<.15	3.6–.3	<.32	17	33	32	<1	Int.	<1	< 2	2.33	300	"
"	Perch (8) 4" to 7"	57	57403	.27	.017	.08	.30	.05	.2	<.02	.26	16.0	2.8–.5	<.15	3.6–.4	<.26	13	33	34	<1	50	<1	< 2	2.40	260	"
"	Perch (2) 10" to 11"	58	57404	.05	.069	.10	.28	.27	.16	.05	.36	16.0	2.6–.5	<.15	3.5–.3	<.31	27	47	70	5.3	50	<1	< 2	2.02	450	"
Lower St. Louis River	Carp 27.0"	59	57405	.03	.019	.26	.34	.20	<.1	.07	.26	20.0	2.0–.4	<.15	3.6–.3	<.14	50	310	56	3.3	Int.	<1	< 2	N.A.	1000	7/16/74
"	Carp 26.0"	60	57406	.03	.031	.05	.36	.24	<.1	.03	.23	18.0	3.1–.6	<.15	2.9–.3	<.10	49	138	40	8	50	<1	< 2	12.14	560	"
"	Carp 19.0"	61	57407	.12	.013	.04	.22	.06	<.1	<.02	.22	14.0	2.3–.4	<.15	3.5–.4	<.18	10	16	20	<1	Int.	<1	< 2	5.47	400	"
"	Carp 19.0"	62	57408	.03	.13	.12	1.1	.11	<.1	<.02	.26	24.0	2.6–.4	<.15	3.4–.3	<.13	23	44	33	5.6	50	<1	< 2	N.A.	315	"
"	Carp 19.0"	63	57409	.26	.021	.09	.29	.12	<.1	.03	.17	19.0	2.6–.4	<.15	3.7–.3	<.15	9	20	24	<1	20	<1	< 2	2.90	190	"

1. Gross Spectrum by radioactivity.

N.A. – Not Available

Int. – Interference

TABLE 4.6-11

MERCURY CONCENTRATIONS IN FISH TISSUE FROM LAKE SUPERIOR

Date and Location	Species	Range (ppm)	Mean (ppm)	Source
1967-68	American smelt	0.08-0.31	0.20±0.07	56
lakewide	Bloater	0.09-0.31	0.18±0.02	
	Burbot	0.39-1.17	0.78±.39	
	Kiyi	0.15		
	Lake herring	0.15-0.45	0.23±0.06	
	Lake trout	0.19-0.58	0.33±0.05	
	Lake whitefish	0.03-0.47	0.14±0.06	
	Longnose sucker	0.07-0.12	0.09±0.03	
	Menomonee whitefish	0.13-0.14	0.13±0.004	
	Ninespine stickleback	0.96		
	Shortjaw cisco	0.41		
	Slimy sculpin	1.13		
	Trout perch	0.24		
1976 Peninsula Harbor	Lake trout	0.71-1.90	0.98	107
	Whitefish	0.08-2.10	0.86	
	White sucker	0.07-2.10	0.79	
1976 Batchawana Bay	Lake trout	0.11-0.60	0.38	107
1976 Goulais Bay	Rainbow trout		0.43	107
1976 Pancake River	Rainbow trout	0.08-0.29	0.14	107
1976 Red Rock	Smelt	0.09-0.48	0.17	107

FIGURE 4.6-1

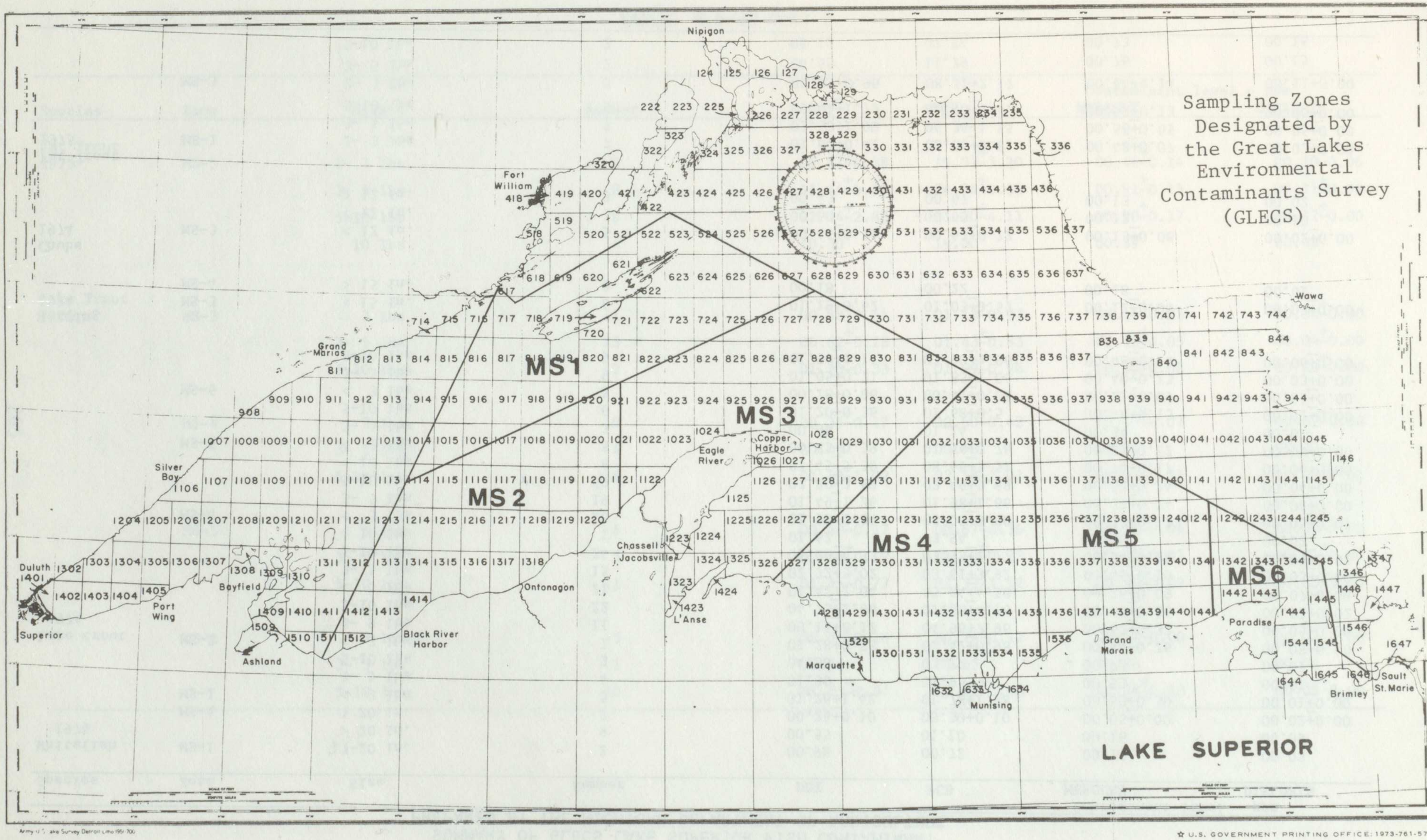

Sampling Zones
Designated by
the Great Lakes
Environmental
Contaminants Survey
(GLECS)
LAKE SUPERIOR
MS1
MS2
MS3
MS4
MS5
MS6
Nipigon
Fort William
Grand Marais
Silver Bay
Duluth
Superior
Port Wing
Bayfield
Ashland
Black River Harbor
Ontonagon
Chassell
Jacobsville
L'Anse
Eagle River
Copper Harbor
Marquette
Munising
Grand Marais
Paradise
Wawa
Brimley
Sault St. Marie
Army U.S. Lake Survey Detroit
U.S. GOVERNMENT PRINTING OFFICE: 1973-761-574

TABLE 4.6-12

SUMMARY OF GLECS LAKE SUPERIOR FISH CONTAMINANT
PREPARED BY THE MICHIGAN DEPARTMENT OF AGRICULTURE

Species	Zone	Size	Number	Contaminant level - ppm DDT	PCB	MERCURY	DIELDRIN
Whitefish 1974	MS-1	17-20 in.	2	00.98	00.72	00.17	00.05
		> 20 in.	4	00.55	01.10	00.16	00.09
	MS-4	> 20 in.	7	00.26±0.10	00.30±0.10	00.05±0.00	00.02±0.00
	MS-1	< 3 lbs	5	01.26±1.42	01.78±1.98	00.53±0.30	00.01±0.00
		3- 5 lbs	4	01.30	01.95	00.53	00.01
		5-10 lbs	3	04.58	03.77	00.75	00.01
Lake trout 1974	MS-2	< 3 lbs	7	01.28±0.53	02.42±0.98	00.44±0.26	00.08±0.90
		3- 9 lbs	11	03.15±2.12	04.96±2.96	00.62±0.32	00.05±0.00
		5-10 lbs	22	04.73±2.66	07.66±4.76	00.69±0.26	00.07±0.02
		< 3 lbs	21	01.47±2.04	03.04±4.58	00.26±0.09	00.07±0.08
		3- 5 lbs	15	02.72±3.02	03.61±3.92	00.46±0.19	00.03±0.00
		5-10 lbs	24	05.20±4.33	03.95±2.77	00.54±0.16	00.09±0.07
		> 10 lbs	1	01.62	03.94	00.30	00.02
	MS-4	< 3 lbs	26	01.90±2.34	03.08±3.90	00.32±0.17	00.05±0.07
		3- 5 lbs	19	01.49±1.26	01.98±1.66	00.37±0.24	00.04±0.00
		5-10 lbs	52	02.80±3.62	03.49±3.69	00.52±0.24	00.04±0.00
		>10 lbs	6	07.45±5.39	08.68±5.51	00.74±0.17	00.06±0.00
	MS-5	< 3 lbs	5	00.85±0.39	01.56±0.76	00.27±0.12	00.02±0.00
		3- 5 lbs	3	00.68	01.14	00.34	00.01
		5-10 lbs	6	01.20±0.36	01.68±0.5	00.46±0.13	00.02±0.00
	MS-6	< 3 lbs	5	00.28±0.06	00.41±0.08	00.21±0.09	00.01±0.00
		3- 5 lbs	9	01.05±0.71	01.83±1.06	00.40±0.13	00.03±0.00
		5-10 lbs	9	01.90±1.11	02.90±1.96	00.48±0.14	00.06±0.00
Herring 1974	MS-3	< 15 in.	6	01.19±0.62	01.03±0.55	00.12±0.06	00.03±0.00
	MS-4	> 15 in.	3	00.18	00.22	00.18	00.01
Chubs 1974	MS-3	< 12 in.	5	00.46±0.25	00.62±0.22	00.13±0.08	00.02±0.00
		< 12 in.	3	00.60	00.69	00.12	00.10
		> 12 in.	3	00.43	00.67	00.13	00.02
Fat Trout 1975	MS-1	2- 3 lbs	7	01.64±0.41	02.06±0.81	00.48±0.07	00.03±0.00
		3- 5 lbs	7	02.58±1.09	04.34±1.55	00.56±0.05	00.05±0.00
		5-10 lbs	5	09.44±1.79	06.90±3.42	00.57±0.13	00.06±0.00
	MS-3	2- 3 lbs	5	03.05±0.96	08.51±2.17	00.64±0.14	00.11±0.00
		3- 5 lbs	2	04.55	11.29	00.76	00.15
		5-10 lbs	2	05.12	07.74	00.73	00.16

TABLE 4.6-12 CONT'D

Species	Zone	Size	Number	DDT	PCB	Contaminant level - ppm MERCURY	DIELDRIN
Fat Trout							
1975	MS-5	2- 3 lbs	6	09.21±6.38	19.37±3.20	00.46±0.14	00.10±0.06
		3- 5 lbs	8	11.64±6.28	24.54±0.33	00.91±0.15	00.11±0.03
		5-10 lbs	6	22.24±2.83	31.20±4.11	00.90±0.17	00.12±0.00
		10 lbs	4	10.30	19.00	00.89	00.08
Lake Trout							
1975	MS-3	3 lbs	11	00.58±0.54	01.13±0.97	00.14±0.03	00.04±0.00
		3- 5 lbs	13	00.62±0.28	01.43±0.83	00.18±0.05	00.04±0.00
		5-10 lbs	12	01.10±0.33	01.99±0.96	00.30±0.08	00.05±0.00
	MS-4	3 lbs	10	00.35±0.17	00.60±0.42	00.10±0.03	00.02±0.00
		3- 5 lbs	4	00.43	00.93	00.12	00.02
		5-10 lbs	28	01.43±1.02	02.58±2.01	00.24±0.11	00.04±0.00
	MS-5	3 lbs	6	00.40±0.17	00.67±0.36	00.16±0.04	00.03±0.00
		3- 5 lbs	5	00.64±0.19	01.13±0.21	00.20±0.07	00.04±0.00
		5-10 lbs	11	01.43±0.77	02.33±1.12	00.35±0.09	00.05±0.00
	MS-6	3 lbs	5	00.55±0.16	00.74±0.11	00.17±0.00	00.02±0.00
		3- 5 lbs	1	00.51	00.65	00.16	00.04
		5-10 lbs	12	01.23±0.37	01.92±0.60	00.28±0.10	00.05±0.00

TABLE 4.6-13

FISH SPECIES COLLECTED AND ANALYZED FOR PCBS

(Ref. 127)

NAME	LETTER CODE
Alewife	A
Bloater Chub	BC
Blue Gill	B
Brook Trout	BT
Brown Trout	BR
Bowfin	BW
Bullhead	BU
Burbot	BB
Carp	C
Chub	CH
Cisco	CI
Coho Salmon	CS
Chinook Salmon	CN
Crappie	CR
Freshwater Drum	D
Gizzard Shad	GS
Herring	H
Lake Trout	LT
Lake Whitefish	LW
Large Mouth Bass	LMB
Menominee	M
Northern Pike	NP
Panfish	PF
Pumpkinseed	P
Rainbow Trout	RT
Redhorse	R
Sheepshead	SH
Small Mouth Bass	SMB
Smelt	SM
Sucker	S
Sunfish	SF
Tiger Trout	TT
Walleye	W
White Bass	WB
White Sucker	WS
Yellow Perch	YP

TABLE 4.6-13 CONT'D

Fish Collection Description					ppm PCB		
SITE	DATE	SPECIES SAMPLED	PORTION ANALYZED(a)	% FAT	LOW	$\bar{x}$	HIGH
St. Louis River Mouth	07/74	5C*	F	6.8	0.2	.5	1.0
Nemedji River Mouth	07/74	6C, 4NP, 10W, 16YP	F	3.5	0.1	0.4	1.3
Lk. Superior Entry	08/76	3W, 1BR, 2S	F	3.1	0.1	0.3	0.7
N. Middle River	08/76	8SM, 4CH	EP	4.9	0.3	0.5	0.8
N.E. Poplar	08/76	3LT, 3BR	F	7.5	0.3	0.8	1.3
3 mi W. Brule River	08/74	30SM, 10W, 1RT	F	2.3	0.1	0.2	0.3
W. Brule River	08/76	1BR, 4W, 4BB, 1H, 5S, 2M	F				
		6MS, 3CH	EP	3.0	0.1	0.6	1.4
Mouth Brule River	07/74	10W, 2RT, 2BR	F	2.7	0.0	0.1	0.2
W. Iron River	08/76	6CH	EP	14.1	1.3	1.3	1.3
		4S	F	3.9	0.4	0.9	1.8
		4W	F	3.9	0.1	0.4	0.7
N. Port Wing	08/76	8SM	EP	2.1	0.3	0.3	0.3
W. Herbster	07/76	1BB	F	1.0	0.1	0.1	0.1
N. Bark Pt.	07/76	2LW	F	10.8	0.2	1.5	2.7
		1LT, 1BB	F	5.3	0.1	0.4	0.8
E. of Squaw Bay	07/76	6CH, 8SM,	EP				
		4S, 2LT	F	4.0	0.4	0.8	1.3
N.W. Eagle Island	07/76	1SI	F	28.8	2.4	2.4	2.4
N. Sand Island	07/76	6CH	EP	7.9	0.8	0.8	0.8
N. Madeline Island	08/76	1SI	F				
		8CH	EP	11.4	0.8	0.8	0.8
Bad River	09/74	1BR, 2NP, 4BU, 4W, 1S	F	2.1	0.1	0.1	0.1
Cheq. Bay	08/74	1H, 16YP, 30SM, 4LW, 3W, 1NP	F	3.9	0.1	0.1	0.1
Kakagon	08/74	7YP, 1NP, 29BU	F	3.0	0.1	0.1	0.1

* Implies 5 carp were analyzed.

(a) F: fillet

EP: edible portion

TABLE 4.6-14

NATIONAL PESTICIDE MONITORING PROGRAM - FISH

FALL 1974 ANALYTICAL RESULTS

(N) - Number of Fish in Sample
(R) - Replicate Sample
(dup) - Duplicate Analysis

PPM - mg/kg wet weight - whole fish

Station No.	Locality and Species	Average Length inches	Average Weight pounds	Lipids %	DDE	TDE	DDT	Total DDT	Est. PCB's	Dieldrin	Other
22	Lake Superior										
	Bayfield, Wisc.										
	Lake Trout	25.6	5.18	11.4	0.80	0.44	1.3	2.54	2.7	0.25	
	Lake Trout (dup)	--	--	11.5	0.99	0.37	1.3	2.66	2.7	0.24	
	Lake Whitefish	18.52	2.1	12.3	0.40	0.06	0.36	0.76	0.7	0.24	0.07 Endrin 0.08 HCB
	Bloater	10.84	0.32	14.1	1.0	0.20	0.62	1.82	2.7	0.09	0.2 HCB
	Bloater (R)	10.5	0.36	11.4	0.41	0.07	0.25	0.73	1.2	0.05	0.06 Endrin 0.01 HCB
102	Lake Superior										
	Keweenaw Point, Mich.										
	Herring	11.56	0.68	9.8	0.43	0.09	1.6	2.12	1.1		0.01 HCB
	Lake Trout	24.18	5.55	24.4	3.3	0.24	1.1	4.64	4.5		0.03 HCB
	Lake Trout (dup)	--	--	24.5	1.8	0.28	0.98	3.06	3.7		0.03 HCB
	Bloater	9.4	0.42	16.6	0.28	0.06	0.03	0.37	0.79		
	Bloater (R)	9.88	0.46	15.3	0.23	0.02	0.21	0.46	0.61		

TABLE 4.6-15

MEAN VALUES OF PERSISTENT ORGANIC RESIDUES IN SELECTED WHOLE FISH FROM VARIOUS REGIONS OF LAKE SUPERIOR AS COMPARED WITH FISH FROM SISKIWIT LAKE, ISLE ROYALE (Ref. 112)

LOCATION	NO. OF FISH	NO. OF COMPOSITES	AVE. LENGTH IN CM.	WEIGHT IN GRAMS	% LIPID	PCB (ppm)	HCB (ppb)	∝BHC (ppb)	HEPTACHLOR EPOXIDE (ppb)	p,p-DDE (ppm)	o,p-DDT (ppm)	p,p-DDD (ppb)	p,p-DDT (ppm)	TOTAL DDT (ppm)	DIELDRIN (ppb)	HCBD[1] (ppm)	DEP[2] (ppm)	DBP[3] (ppm)	DEHP[4] (ppm)
Mean Values Lake Superior Lake Trout Isle Royale Area Group I	11	5	54 (40-76)	1811	12.5	1.7	9*	19	5	.58	.12	21	.14	.86	53	BQT**	.6	0.3	BQT
Mean Values Lake Superior Lake Trout Isle Royale Area Group II	4	3	54 (49-61)	1464	5.0	.3	3	7	BQT	.08	BQT	BQT	BQT	.08	8	BQT	.2	BQT	BQT
Lake Superior Lake Trout Exclusive of Isle Royale Area	10	8	50 (49-61)	1201	2.68	.6	3	4	3	.12	.04	3	.07	.23	15	2.18	BQT	3.2	.3
Lake Superior Lake Trout All Stations	24	16	52 (40-76)	1451	6.19	.9	5	9	3	.26	.06	8	.08	.40	28	1.09	.25	1.7	.2
Lake Superior Lake Trout Isle Royal Area	15	8	54 (40-76)	1701	9.71	1.2	7	15	3	.40	.08	13	.09	.57	41	BQT	.5	.2	BQT
Siskiwit Lake Lake Trout	2	1	55 (43-66)	1617	3.5	1.2	5	11	8	2.37	.03	36	.46	2.89	11	BQT	.4	BQT	BQT
Lake Superior White-Fish Exclusive of Isle Royale Area	4	2	51 (45-61)	1077	3.15	.2	BQT	4	BQT	.03	BQT	BQT	BQT	.03	BQT	BQT	BQT	BQT	BQT
Lake Superior White-fish All Stations	30	6	55 (45-61)	1497	5.06	.2	3	5	2	.12	.02	3	.04	.18	17	BQT	1.32	.04	.4
Lake Superior White-fish Isle Royale Area	4	3	57 (50-62)	1777	6.3	.4	5	6	4	.18	.41	5	.07	.66	29	BQT	2.2	.7	.7
Siskiwit Lake White-fish	4	1	44 (31-52)	1007	3.8	.1	BQT	6	8	.07	BQT	BQT	.09	.16	8	BQT	1.7	BQT	BQT

TABLE 4.6-15 CONT'D

LOCATION	NO. OF FISH	NO. OF COMPOSITES	AVE. LENGTH IN CM.	WEIGHT IN GRAMS	% LIPID	PCB (ppm)	HCB (ppb)	α BHC (ppb)	HEPTACHLOR EPOXIDE (ppb)	p,p-DDE (ppm)	o,p-DDT (ppm)	p,p-DDD (ppb)	p,p-DDT (ppm)	TOTAL DDT (ppm)	DIELDRIN (ppb)	HCBD[1] (ppm)	DEP[2] (ppm)	DBP[3] (ppm)	DEHP[4] (ppm)
Rock of Ages	2	1	64 (58-69)	3348	41.2	8.4	8	16	28	4.80	.12	113	.42	5.45	137	BQT	1.3	BQT	1.3
Rock of Ages	1	1	68 (68)	4082	43	8.2	40	40	BQT	6.70	1.23	197	3.60	11.73	17	BQT	BQT	BQT	BQT
Rock of Ages	1	1	59 (59)	3856	32	6.4	23	37	BQT	4.68	.26	92	3.22	8.24	32	BQT	.3	BQT	BQT
Middle Islands Passage	1	1	68 (68)	4080	40	5.4	22	29	BQT	1.24	.05	35	.25	1.58	42	BQT	2	BQT	BQT
Mean Values			65 (58-69)	3842	39.1	7.1	23	31	7	4.36	.41	219	1.87	6.86	228	BQT	.9	BQT	.3

* Values below indicated thresholds have been regarded as equal to zero for computation of mean values.
** Values labeled BQT were below the threshold of quantification.

[1] Hexachlor Butadiene
[2] Di-ethyl Phthalate
[3] Di-butyl Phthalate
[4] Di-ethyl Hexyl Phthalate

TABLE 4.6-16

ORGANIC COMPOUNDS (NONIONIC) DETECTED (+) AND NOT DETECTED (-) BY COMBINED GAS CHROMATOGRAPHY - MASS SPECTROMETRY IN WHOLE-FISH SAMPLES OF LAKE TROUT FROM THE OPEN WATERS OF LAKE SUPERIOR

COMPOUND	ESTIMATED CONCENTRATION RANGE DETECTED µg/g	APOSTLE ISLANDS	COPPERMINE BANK
Biphenyl	0.01 - 0.1	-	-
Napthalene & methylnapthalenes	0.01 - 0.5	+	+
Phenanthrene - methyl phenanthrenes		+	+
Diethyl phthalate		+	+
Dibutyl phthalate	0.01 - 0.1	+	+
Di-2-ethyl hexylphthalate		+	+
Trichlorobenzene		-	+
Tetrachlorobenzene	0.01 - 0.5	-	+
Pentachlorobenzene		-	+
Hexachlorobenzene		+	+
Chlorobiphenyl (tri- through octachloro PCB's)		+	+
Octachlorostyrene	0.001- 0.01	-	-
1,2,3,4,5,6-Hexachlorocyclohexane			
(alpha isomer)	<0.1	+	-
(gamma isomer)	<0.1	-	+
Heptachlor epoxide	0.1 - 1.0	+	+
Chlordane (cis- and trans-)	0.1 - 1.0	+	+
Nonachlor (cis- and trans-)	0.1 - 1.0	+	+
Oxychlordane	0.01 - 0.1	-	+
Dieldrin	<0.1	-	+
pp' DDT	1 - 10	+	+
op' DDE	0.1 - 1.0	+	+
pp' DDE	1 - 10	+	+
pp' DDD	0.1 - 1.0	+	+
pp' DDMU	<0.01	+	+
Toxaphene components ($C_{10}H_8Cl_{7,8}$, trans-)	0.1 - 1.0	+	+
Methylbenzothiophene	0.01 - 0.1	-	-

TABLE 4.6-17
(Ref. 106)

1973 ANALYSES FOR TFM RESIDUES IN LAKE SUPERIOR FISH

Species and Location	Number Fish	Weight (kg) Mean	Range
Lake trout			
-Munising	11	1.6	0.75-3.5
-Whitefish Point	8	1.1	0.7 -2.2
-Keweenaw Bay	7	0.7	0.5 -1.3

No residues of TFM were found in any samples.
(limit of detection - 0.01 μg/g).

4.7 Data on Wildlife

Table 4.7-1 summarizes data on organic contaminants and mercury in ducks, starlings and eggs of herring gulls. The levels of mercury found in 1970 by the Wisconsin Department of Natural Resources (124) were not significant in the puddle ducks, coots and geese throughout the state. Diving ducks, the blue heron and the hooded merganser were found to contain greater amounts of mercury. However, few samples were taken from the Lake Superior Basin. The analyses of herring gull eggs from Lake Superior showed a diversity of organic contaminants, including mirex (73, 74). Significant declines were observed in DDE levels, and apparent declines were noted for PCB and mirex levels.

The results of a recent (163) study of pectoral tissues of several bird species found in the Duluth-Superior Harbor are shown in Table 4.7-1. The analyses of a first year gull, between 4 and 5 months old, from the Duluth-Superior Harbor revealed several additional contaminants: tetrachloro-heptachlorobiphenyl, pentachloroanisole, hexachlorobenzene, tribromoanisole, pentachlorobenzene, chlordane, nonachlor and mirex.

TABLE 4.7-1

ANALYSES FOR ORGANIC CONTAMINANTS AND MERCURY IN LAKE SUPERIOR WILDLIFE
(mg/kg fresh weight)

DATE	SAMPLING SITE	NO. SAMPLES	SPECIES	PORTION ANALYZED	MIREX	DDE	DDD	DDT	DIEL-DRIN	HEPTA-CHLOR EPOXIDE	BHC	HCB	Hg	PCBs	PCBs AROCLOR 1260	PHOTO MIREX	SOURCE
1970	Totogatic Lake	1	Mallard duck	Muscle									0.02				124
				Liver									0.14				
1970	Bayfield County	1	Wood duck	Muscle									0.01				
				Liver									0.03				
1970	Douglas County	1	Wood duck	Muscle									0.19				
				Liver									0.35				
1970	Totogatic Lake	1	Bufflehead (diving duck)	Muscle									.12				
				Liver									.53				
1970	Totogatic Lake	1	Canvasback	Muscle									.01				
				Liver									.04				
1974	Chippewa County		Starlings			0.06		0.04	0.1	TR	R	0.006		0.5			72
1974-75	Lake Superior	10	Herring gulls	Eggs	0.7 (0.2-5.2)	19 (9-47)	0.2 (TR-0.4)	0.1 (0.2-.6)	0.4 (0.1-1.4)	0.1 (0.7-.4)	-	0.1 (.02-.3)	0.4 (0.2-0.6)	60 (33-148)			73
1975	Silver Island	10	Herring gulls	Eggs	.6±.4	24±11	.1±.04	.07±.03	.04±.3	.2±.08	-	.06±.04		82±33	64±27	-	79
1977	Silver Island	10	Herring gulls	Eggs	.2±.2	12±7	.15±.06	.06±.03	.4±.2	-	.03±.02	.12±.07		55±22	44±19	.12±.10	79
1975	Mamainse Island	10	Herring gulls	Eggs	1.3±1.7	22±9	.08±.04	.19±.08	.3±.1	.14±.06	-	.12±.04		71±38	54±29		
1977	Mamainse Island	10	Herring Gulls	Eggs	.4±.8	12±4	.21±.14	.07±.06	.4±.2	-	.03±.02	.13±.06		56±20	47±16	.2±.3	
1977-78	Duluth-Superior Harbor	2	Herring Gulls	Pectoral Tissue		15.3						.06-.45		69-93			162
		1	Herring Gull (1st year)	Pectoral Tissue		3.5						.19		25			
		1	Herring Gull (2nd year)	Pectoral Tissue		2.0						.06		12			
		1	Common Tern	Pectoral Tissue		2.4						.10		19			
		3	Mallard	Pectoral Tissue		.01-.04						0.2-.35		.19-.25			
		1	Scaup	Pectoral Tissue		.09						.28		.66			
		1	Belted Kingfisher	Pectoral Tissue		.78						.05		2.14			
		1	American coot	Pectoral Tissue		.02						.04		.23			

5 LAKE MICHIGAN BASIN

There are several data sources on the environmental quality of the Lake Michigan Basin. In July 1977, "An Environmental Information Directory" was published (130) as part of the Chicago Lakefront Demonstration Project. Within the directory, research and monitoring programs in the southern basin of Lake Michigan are listed under the headings of: earth characteristics; coastal processes; hydrology; water quality; meteorology; air quality; biology of plants; biology of animals; and environmental health. In 1976, the Argonne National Laboratory published a series of reports entitled "Environmental Status of the Lake Michigan Region" to "provide a reasonable comprehensive descriptive review and analysis of natural features and characteristics, as well as past, present, and proposed natural processes and human activities, that influence the environmental conditions of Lake Michigan, its watershed, and certain adjacent metropolitan areas." Volume 3 of the series which is entitled "Chemistry of Lake Michigan" (131), provides a "synoptic review of data collected over the past twenty years on the Chemistry of Lake Michigan." Another extensive source of information is the report by Copeland and Ayers entitled "Trace Element Distributions in Water, Sediment, Phytoplankton, Zooplankton and Benthos in Lake Michigan: A Baseline Study with Calculations of Concentration Factors and Buildup of Radioisotopes in the Food Web" (132). General information on the chemistry of Lake Michigan is also found in the report of the Great Lakes Basin Framework Study entitled "Limnology of Lakes and Embayments (Appendix 5)" (133). The publication "The Green Bay Watershed - Past/Present/Future" is also recommended (173). The U.S. EPA Region V Great Lakes Office is currently preparing a report on the results of its 1976-77 Lake Michigan cruises.

5.1 DATA ON WATER QUALITY

Heavy Metals

Table 5.1-1 summarizes the heavy metal concentrations in nearshore and open waters of Lake Michigan, which have been reported by various investigators. Much of the data for the years 1969 to 1971, were obtained from reference 131. In many instances it was difficult to determine if the values given were for "dissolved" or "total" metals. Table 5.1-2 shows the results of a study by Leland (134) to determine the concentrations of solute trace elements in the epilimnion of southern Lake Michigan. Estimated ranges and averages of trace metal concentrations in the offshore waters of Lake Michigan are shown in Table 5.1-1 and 5.1-3 (131, 132). Distribution of zinc as determined by the Environmental Research Group (132) is shown in Figures 5.1-1.

The Michigan Department of Natural Resources (135) reported the results of its regular studies of Lake Michigan waters from water treatment plant intakes and from the mouths of various tributaries. Their results are summarized in Table 5.1-1. Nearshore data were reported in 1978 by PLUARG (9) and by Rossman (136), and the data are also presented in Table 5.1-1.

Table 5.1-4 summarizes the heavy metal concentrations in Lake Michigan tributaries as reported by the Michigan Department of Natural Resources (135). Tables 5.1-5 and 5.1-6 show the results of two other tributary studies (137, 138).

Organic Contaminants

From 1962 to 1971 significant amounts of data were obtained for phenol concentrations in southern Lake Michigan waters. Table 5.1-7 shows some phenol levels which were observed within a nine year period (131). In the late 1960's, DDT, DDD, DDE and dieldrin were found in measureable quantities (131, 139), and during the 1970's some water samples had PCBs in concentrations of 0.012 to 0.056 μg/L (131, 140). However, PCBs could not be detected in many of the samples. Since 1974 the Michigan Department of Natural Resources has regularly analyzed the Lake Michigan nearshore waters and tributaries, for approximately 15 organic compounds including PCBs, phthalate esters and chlorinated pesticides. The results which are shown in Tables 5.1-8 and 5.1-9 indicate that phthalate esters are frequently found at elevated levels.

The most extensive attempt to identify organic contaminants in the waters of the Lake Michigan Basin was undertaken by Ewing and Chian (18) in 1975-76. The sampling sites are listed in Table 5.1-10. Several samples may have been taken from each site, and the reader is referred to reference 18 for further details. The observed concentrations of "volatile," "acid-extractable," and "base-extractable" organic compounds, are listed under each sampling site (in accordance to the site number designated in Table 5.1-10), in Tables 5.1-11 to 5.1-13. Ranges of concentrations are denoted at the sites where several samples were taken.

TABLE 5.1-1

HEAVY METAL CONCENTRATIONS IN LAKE MICHIGAN WATERS

DATE & SAMPLING FREQUENCY	STATION	ppb(μg/L)[a] ARSENIC	CADMIUM	CHROMIUM	COBALT	COPPER	LEAD	MERCURY	MOLYBDENUM	NICKEL	SELENIUM	SILVER	VANADIUM	ZINC	INFORMATION SOURCE
1969-70 (3 times)	12 inshore stations (b)	.98 (.17-1.9)	-	1.6 (.5-3.2)	0.2 (.03-.57)	N.D.-18	-	.03 (.02-.03)	N.D.-4.8	-	.08 (.02-.17)	.32 (.06-1.1)	.24 (.15-.42)	21 (2.2-80)	131
	8 offshore stations (b)	1.0 (.38-2.6)	-	1.8 (.8-4.)	.17 (.06-.55)	N.D.-17	-	.02 (.01-.02)	N.D.-4.8	-	.1 (.08-.14)	.32 (.18-1.2)	.23 (.15-.32)	16 (1.9-62)	131
1970	10m depth near:	-	1.0(e)	-	-	.8(e)	.2(e)	-	-	-	-	-	-	-	
	Waukegon	-	-	-	-	19 (d)	3.3(d)	-	-	-	-	-	-	-	
	Ludington	-	-	-	-	.4(d)	.6(d)	-	-	-	-	-	-	-	
1970-71 (monthly)	Kenosha Public Water Supply Intake	1.6 (.7-3.7)	<1	<1-7	-	-	2 (1-5)	.22 (.11-.53)	- -	<3 <3	- -	- -	- -	160 (43-450)	131
	Waukegon Generating Station Intake	2.4 (.6-4.9)	<1	4 (1-14)	-	14 (1-35)	9 (4-15)	.84 (.07-2.97)	- -	≤3 ≤3	- -	- -	- -	- -	
	North Chicago Public Water Supply Intake	1.4 (.5-3.4)	<1	2	-	<1-2	2	.56 (.06-3.)	-	≤3	-	-	-	8 (2-26)	131
1969-71	Estimated General Offshore Concentration	1-2	<1	.5-6	.03-.6	5-10	1-8	.02-.4	N.D.-2	2-5	.1-1	.3(b)	.2(b)	2-60	131
1974-77 (annual)	Ford River WTP Mouth of Ford River	<1-2	.5-2	-	-	1-3	<1-34	<.1-.3	-	11-12	<2	<1	-	9-15	135
1973-77 (annual)	Grand Haven Mouth Grand River	<1-2	1-3	-	-	5-6	20-22	<.1-.2	-	33-34	<1	<1	-	5-46	135
1972-77 (annual & quarterly)	City of Holland WTP	<1-.4	<.1-.5	2-6	-	8-16	<1-6	<.1-.4	-	<5-9	<2	<1	-	2-15	135
1974-77 (annual)	Manistique River Mouth	<1-.3	<.1-2	-	-	1-3	<1-9	<.1-.3	-	6-8	<2	<1	-	6-14	135
1974-77 (annual)	Masonville, White Fish River Mouth	<.2	1-3	--	-	<1-4	<1-10	<.1-.8	-	9-11	<1	<1	-	6-22	135
1972-77 (annual & quarterly)	Menominee Water Intake (Green Bay)	<1-5	<.1-1	<1-3(b)	-	7-34	<1-30(b)	<.1-.4	-	5-16	<1	<1-2(b)	-	43-300	135

TABLE 5.1-1 CONT'D

DATE & SAMPLING FREQUENCY	STATION	ARSENIC	CADMIUM	CHROMIUM	COBALT	COPPER	LEAD	MERCURY	MOLY DENUM	NICKEL	SELENIUM	SILVER	VANADIUM	ZINC	INFORMATION SOURCE
		µg/L													
1972-77 (annual & quarterly)	St. Joseph Water Intake	<1-1	<.1-1	-	-	22-83	<1-4	<.1-.4	-	6-28	<1	-	3-26	3-26	135
1973-77 (annual)	St. Joseph River Mouth	1-2(b)	<1-3	-	-	6-17(b)	7-26	<.2-1.	-	21-22	<1	<1	-	8-18	135
1973-77 (annual)	Saugatuck, Kalamazoo River Mouth	<1-3(b)	.5-3	-	-	6-11(b)	6-21	<.1-.4	-	22-26	<1	<1	-	15-16	135
1973-77	Traverse City (annual)	<1-.4	.2-2	-	-	2-8(b)	1-24(b)	<.2-.6	-	10-13	<1	< 1-2(b)	-	8-37(b)	135
1974-76	Nearshore between St. Joseph and Michigan City														
	-Epilimnion(f)									.07				8	136
	-Hypolimnion(f)									.2				8	
	-Epilimnion(b)			1.7	1.3	2.3			12	7.0				4.6	136
	-Hypolimnion(b)			1.3	1.2	2.4			15	7.0	4.8			4.8	
1977	Nearshore to 30 km from shore	<2	<2	6.8		1.8	7.2								9

(a) assumed to be "total" unless otherwise specified

(b) "dissolved"

(c) higher values than those indicated in this table were noted in the vicinity of power plants

(d) acid exchangeable

(e) "free" metal

(f) particulate fraction

FIGURE 5.1-1

ZINC DISTRIBUTION IN LAKE MICHIGAN THIRD CRUISE WATER (PPB)

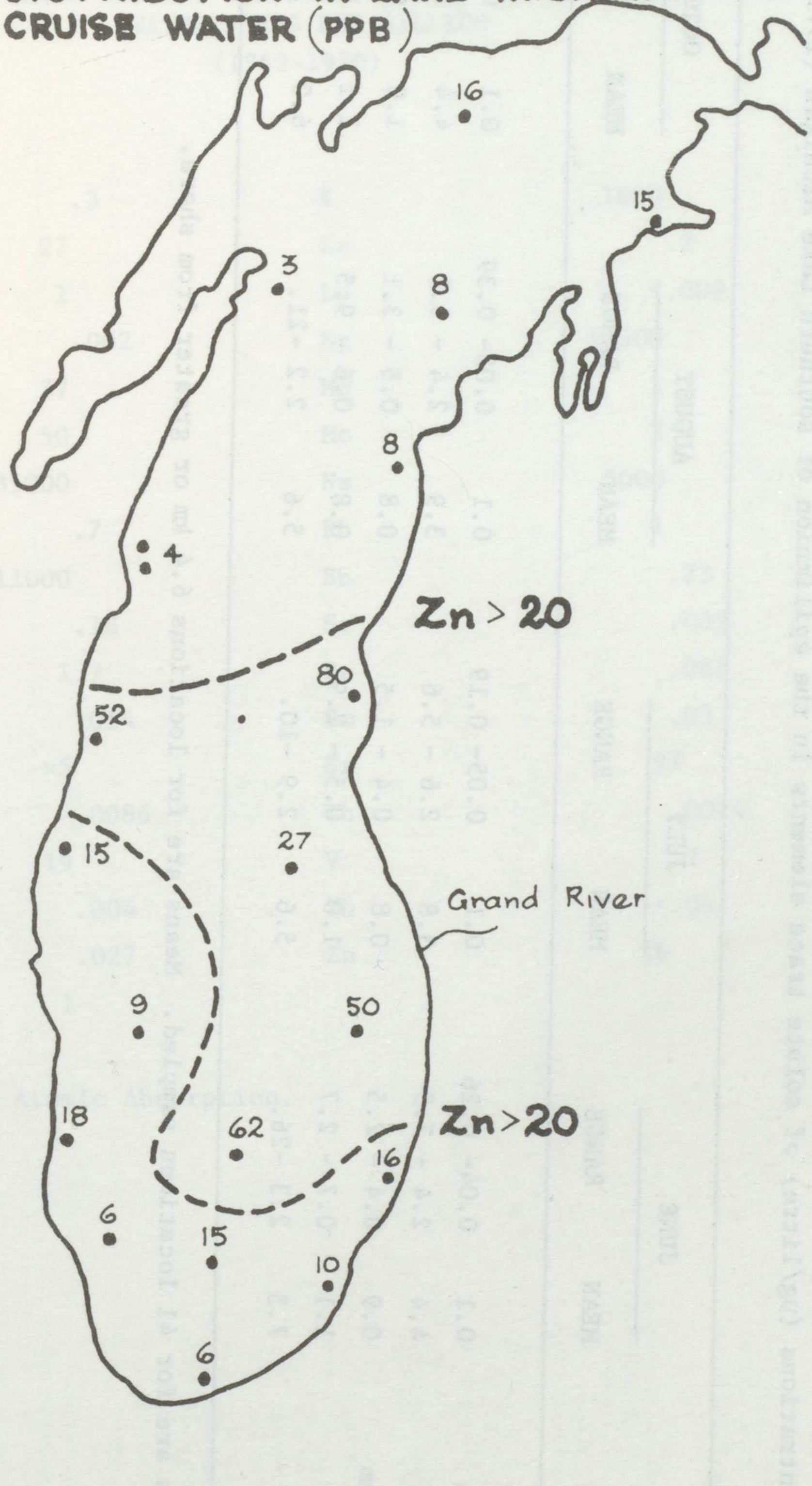


TABLE 5.1-2

(Ref. 134)

Concentrations (μg/litre) of solute trace elements in the epilimnion of southern Lake Michigan (1971)*

ELEMENT	JUNE MEAN	JUNE RANGE	JULY MEAN	JULY RANGE	AUGUST MEAN	AUGUST RANGE	OCTOBER MEAN	OCTOBER RANGE
Cadmium	0.1	0.04- 0.26	0.1	0.05- 0.19	0.1	0.05- 0.39	0.1	0.07- 0.25
Copper	4.4	2.4 - 7.5	3.8	2.6 - 5.6	3.9	2.4 - 5.1	4.4	2.4 - 6.1
Chromium	0.9	0.4 - 2.5	0.8	0.4 - 1.5	0.8	0.5 - 3.1	1.0	0.5 - 3.5
Lead	1.1	0.7 - 2.7	1.0	0.5 - 2.9	0.8	0.6 - 9.5	1.1	0.7 - 4.6
Zinc	7.5	2.3 -26.	5.6	2.9 -10.	5.6	2.2 -21.	6.0	3.4 -22.

*Ranges are for 41 locations sampled. Means are for locations 6.4 km or greater from shore.

TABLE 5.1-3

(Ref. 132)

AVERAGE TRACE ELEMENT CONCENTRATIONS FOUND IN LAKE MICHIGAN WATER PARTS PER BILLION (1969-1970)

Ag	.3	K	1600
Al	27	La	.2
As	1	Lu	<.009
Au	.002	Mg	11500
Ba	37	Mn	1
Br	50	Mo	2[1]
Ca	35000	Na	5000
Ce	.7	Rb	1
Cl	11000	Sb	.23
Co	.18	Sc	.003
Cr	1.7	Se	.083
Cs	.014	Sm	.03
Cu	≃5	Sr	97
Eu	.0086	Th	.0024
Fe	19	V	.2
Hf	.004	Yb	<.01
Hg	.027	Zn	16
I	1		

1.) Data by Atomic Absorption.

TABLE 5.1-4

HEAVY METAL CONCENTRATIONS IN WATERS OF TRIBUTARIES TO LAKE MICHIGAN

ppb (µg/ℓ)[a]

Date	Stations	No. Samples	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn	Information Source
1971	16 rivers (b)(d) (See Table 5.1-5)	5	-	-	.4-22	-	1.5-10	-	-	1.8-31	2.8-41	-	-	-	1.5-10.8	137
1971(?)	21 tributaries(c) (See Table 5.1-6)		-	-	.1-6	-	-	.1-6	-	.2-10	-	-	.1-9	.3-7	-	138
1974-77	Betsie River, MI Crystal Lake Twp.	5	<1-.4	.1-2	-	-	2-9(d)	<1-15(d)	<.1-.3	-	10-13	<2	<1-2(d)	-	8-23(d)	135
1973-77	Black Creek, MI Egelston Twp	5	<1-2	1-3	-	-	2-6(d)	2-18	<.2-.1	-	12-24(d)	<2	<1-1(d)	-	13-31(d)	135
1974-77	Escanaba River, MI Cornell Twp.	4	<.2-1(d)	.4-2	-	-	1-4	2-8	.1-.4	-	6-15(d)	<1-1(d)	<1-1.7(d)	-	6-35(d)	135
1974-77	Escanaba River, MI Wells Twp.	4	<.2-1(d)	.4-2	-	-	4	6-7	.2-.4	-	10-24(d)	<2	<1-1.3(d)	-	12-24	135
1975-77	Grand River, MI Ada Twp.	3	<1-3(d)	.5-3	-	-	3-5	2-18	<.2	-	24-32	<2	<1	-	10	135
1973-77	Grand River, MI Delta Twp.	36	2-4	<.1-12	-	-	2-100	<1-210	<.2-1.2	-	<5-170	<1	<5-3(d)	-	2-120	135
1971-77	Grand River Water Works Intake	10	<1-2	<.1-2	2-3	-	4-32(d)	<1-16	<.2-1.7	-	20-42	<2	<1-2(d)	-	11-34	135
1973-77	Grand River Grandville, MI.	14	<1-4(d)	1-3	-	-	4-28	3-27	<.2-.1	-	32-34	<2	<1	-	14-22	135

TABLE 5.1-4 CONT'D

HEAVY METAL CONCENTRATIONS IN WATERS OF TRIBUTARIES TO LAKE MICHIGAN

ppb (μg/ℓ)[a]

Date	Stations	No. Samples	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn	Information Source
1973-77	Grand River Rives Twp.	11	2-4[(d)]	4-6	-	-	8-17	13-47	<.2-.2	-	20-42	<2	<1-2[(d)]	-	11-34	135
1974-77	Grand River Windsor Twp.	72	-	<.1-16	-	-	<1-75	<1-170	-	-	<5-110	<2	-	-	<1-190	135
1973-77	Kalamazoo River Cooper Twp.	11	<1-2	.2-5[(d)]	-	-	8-18	2-22	<.2-1	-	21-29	<2	<1-1[(d)]	-	16-270	135
1975-77	Kalamazoo River Comstock, MI	5	<1-2	.1-3	-	-	6-13	<1-19	<.1-.5	-	24-26	<2	<1	-	10-12	135
1973-77	Manistee River Manistee, MI	5	-	-	-	-	2-3[(d)]	-	-	-	-	<2	<1-2[(d)]	-	-	135
1974-77	Manistique River Germfask Twp.	4	<1-.2	<.1-1	-	-	<1-3	<1-10	<.1-.3	-	5-7	<1-1[(d)]	<1-.9	-	8-28	135
1974-77	Menominee River Mellen Twp.	4	<1-1	1-4	-	-	2-25[(d)]	2-14	<.1-.7	-	8-11	<2	<1	-	16-38	135
1973-77	Mosquito Creek Muskegon Twp.	7	1	.5-3	-	-	1-3	2-30	<.2-.2	-	17-18	<2	<1	-	10-24[(d)]	135
1973-77	Muskegon River Muskegon Twp.	6	<1-2[(d)]	.5-2	-	-	<1-4[(d)]	3-13	<.1-.2	-	10-14	<2	<1	-	4-52[(d)]	135
1975-77	Pere Marquette R. Custer Twp.	4	<1-1	1-2	-	-	<1-2	4-10	<.1-.8	-	10-12	<2	<1	-	4-10[(d)]	135
1974-77	Pere Marquette R. Pere Marquette Twp.	5	<1-1	1-2	-	-	<1-2	3-11	<.1-.3	-	14-22	<2	<1	-	8-72	135

TABLE 5.1-4 CONT'D

HEAVY METAL CONCENTRATIONS IN WATERS OF TRIBUTARIES TO LAKE MICHIGAN

ppb (µg/ℓ)[a]

Date	Stations	No. Samples	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn	Information Source
1975-77	Platte River Homestead Twp.	3	<1-.2	<.1-2	–	–	2	<1-8	<.2	–	8-12	<2	<1	–	4-26	135
1975-77	Platte River Inland Twp.	3	<1-.2	<.1-2	–	–	1-3	<1-13[d]	<.2-.1	–	9-11	<2	<1	–	3-10	135
1973-77	Rabbit River Hopkins Twp.	6	<1-2	<.3-5[d]	–	–	3-16[d]	2-19	<.2-.1	–	15-22	<2	<1	–	14-120	135
1973-77	St. Joseph River Bertrand Twp.	5	<1-2[d]	.4-6	–	–	9-10	<1-26	<.1-1	–	22-24	<2	<1	–	16-17	135
1973-77	White River Whitehall Twp.	5	<1-2[d]	1-2	–	–	2	2-12	<.2	–	12-14	<2	<1-1[d]	–	4-160	135

(a) "total" unless otherwise specified

(b) range of means for the 16 rivers

(c) range of upper limit concentrations

(d) dissolved fraction

TABLE 5.1-5 SOLUBLE ELEMENTS FOUND IN WATER SAMPLES FROM THE MOUTHS OF LAKE MICHIGAN TRIBUTARIES (137)

Mean concentration and coefficient of variation.

River	Cond[1]	Ca[2]	Mg[2]	Na[2]	K[2]	Fe[3]	Mn[3]	Cu[3]	Ni[3]	Cr[3]	Mo[3]	Zn[3]	Sr[3]	Ba[3]
St. Joseph	506.0	67.1	25.0	12.7	2.6	24.4	5.1	4.2	17.5	2.1	9.5	6.9	104.9	28.6
	0.1	0.1	0.1	0.2	0.2	0.5	0.3	0.2	0.6	0.4	0.4	0.8	0.3	0.2
Black	420.2	46.5	20.2	18.1	2.0	36.7	21.6	2.8	8.3	2.0	4.8	5.2	144.3	24.8
	0.1	0.1	0.3	0.4	0.3	0.1	0.7	0.2	0.4	0.2	0.5	0.8	0.2	0.0
Kalamazoo	582.8	75.3	25.3	24.7	2.9	46.6	30.8	2.8	17.0	2.1	8.2	4.8	134.1	33.4
	0.0	0.1	0.1	0.2	0.1	0.6	1.0	0.1	0.4	0.2	0.4	0.5	0.2	0.1
L. Macatawa	413.0	39.3	13.8	25.6	3.1	52.7	17.1	2.4	8.3	1.4	6.6	3.9	123.1	34.1
	0.3	0.2	0.1	0.5	0.2	0.9	1.1	0.4	0.4	0.6	0.5	0.6	0.3	0.5
Pigeon	323.0	44.2	11.0	4.8	2.9	89.6	35.5	2.0	7.3	1.4	30.9	3.9	109.3	15.8
	0.1	0.1	0.1	0.1	0.1	0.4	0.4	0.7	0.3	0.5	0.2	0.6	0.1	0.1
Grand	686.6	76.7	26.9	32.1	3.5	33.8	17.8	10.4	41.0	22.4	9.0	10.8	266.6	24.4
	0.0	0.1	0.1	0.2	0.1	0.3	0.9	0.8	0.5	1.1	0.3	1.0	0.3	0.1
Muskegon	335.8	41.4	13.4	11.3	1.8	37.1	7.1	3.1	8.0	4.5	7.1	4.6	123.0	10.2
	0.1	0.1	0.1	0.2	0.1	0.7	1.5	0.2	0.2	0.6	0.2	0.5	0.2	0.1
White River	401.4	43.4	17.2	17.2	1.5	56.5	14.4	1.5	7.4	1.5	4.1	4.8	147.9	11.7
	0.2	0.1	0.1	0.7	0.2	0.7	0.6	0.1	0.3	0.3	0.3	0.8	0.2	0.1
Pentwater	356.5	43.9	18.8	7.8	1.7	13.8	2.0	2.0	7.6	1.5	4.7	3.6	126.3	11.4
	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.3	0.4	0.1	0.3	0.5	0.2	0.2
Pere Marquette	436.5	59.7	17.1	12.1	1.9	30.3	9.1	1.7	7.5	1.6	3.9	4.1	270.7	13.5
	0.1	0.1	0.2	0.2	0.3	0.7	0.7	0.2	0.3	0.7	0.4	0.4	0.4	0.2
Lincoln	326.0	42.9	16.2	3.5	1.6	71.6	12.5	2.2	5.0	1.0	2.4	3.7	93.5	11.9
	0.1	0.1	0.1	0.1	0.2	0.7	0.6	0.4	0.7	0.5	0.2	0.5	0.2	0.3
Big Sable	296.5	35.1	12.9	6.8	1.2	13.9	3.9	2.6	5.6	0.6	2.6	2.0	124.9	10.2
	0.1	0.1	0.1	0.1	0.2	0.6	0.7	0.7	0.2	0.8	0.3	0.1	0.2	0.1
Manistee	713.7	80.4	14.7	36.5	3.0	38.8	7.6	2.4	8.4	2.1	5.9	2.2	582.8	10.7
	0.1	0.3	0.1	0.3	0.1	0.3	0.7	0.1	0.1	0.3	0.2	0.3	0.1	0.2
Platte	322.0	38.5	12.6	3.3	0.9	12.2	1.6	1.7	5.2	0.4	3.6	4.1	98.2	9.8
	0.1	0.0	0.1	0.1	0.1	0.0	0.2	0.1	0.2	0.3	0.4	0.5	0.2	0.0
Betsie	332.5	39.1	14.3	4.2	1.1	37.6	4.5	1.7	4.5	0.6	3.4	1.5	104.8	12.3
	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.1	0.2	0.1	0.1	0.4	0.1	0.0
Boardman	351.5	43.0	12.0	4.4	1.2	20.4	8.6	1.9	2.8	0.9	1.8	2.2	61.0	9.7
	0.0	0.2	0.1	0.1	0.0	0.5	0.2	0.1	1.0	0.1	0.2	0.0	0.4	0.0

[1]μmho/cm. [2]ppm. [3]ppb.

TABLE 5.1-6
(Ref. 138)

Upper limit concentrations for selected trace elements in Lake Michigan tributaries (μg/l).

River	Na	Mg	Al	Si	K	V	Fe	Mn	Br	Rb	Mo	Ag	Cd	Sn	Sb	I	Ba	La	Pb	Bi	U
St. Joseph	20000	10000	90	3400	10000	2	140	5	110	5	0.5	0.2	0.1	2	1	30	30	ND	2	0.1	0.1
Black	160000	45000	160	14000	20000	5	180	50	180	5	1	0.4	0.5	2	2	20	30	ND	0.1	0.1	0.1
Kalamazoo	--	--	400	2400	--	2	--	20	--	--	--	0.5	0.1	2	2	25	45	ND	0.5	0.1	0.3
Black Creek	15000	5000	260	1100	4000	3	120	5	55	2	0.6	0.7	0.1	3	1	20	40	0.1	0.1	0.1	0.1
Grand	30000	15000	40	800	5000	2	110	6	160	25	2	2	6	10	10	100	50	0.6	1.1	0.1	0.5
Muskegon	1000	1000	10	600	1000	1	60	1	70	1	1	3	0.1	1	4	10	20	0.1	0.1	0.1	0.1
White	9000	3000	10	600	1000	6	35	2	130	ND	0.9	9	1	2	10	7	30	0.3	0.1	0.1	0.1
Fox (Green Bay)	5000	7000	200	800	3000	2	60	9	65	1	0.7	1	1	0.4	5	20	20	ND	0.1	0.1	0.1
Fox (Appleton)	3000	6000	50	500	3000	2	45	2	40	1	0.6	1	0.1	1	1	20	10	ND	0.3	0.1	0.3
Fox (Oshkosh)	4000	9000	50	3300	4000	2	170	1	55	2	0.2	0.2	0.1	0.4	0.4	20	7	ND	0.1	0.1	0.3
Kewanee	11000	25000	300	5300	20000	2	190	8	70	5	0.8	0.3	0.1	1	1	20	10	0.1	0.3	0.1	0.3
East Twin	40000	70000	100	4600	20000	2	410	10	110	25	2	0.6	0.8	1	1	10	20	ND	0.3	0.1	0.3
West Twin	15000	25000	200	5400	8000	4	290	10	50	4	1	0.9	5	2	3	25	30	ND	2	0.1	0.5
Manitowoc	20000	30000	100	5500	10000	5	250	20	110	10	3	0.8	3	2	4	25	30	0.3	0.9	0.1	0.3
Sheboygan	40000	40000	90	5700	8000	6	260	20	140	10	2	0.9	3	4	6	25	30	0.3	6	0.1	0.8
Milwaukee	70000	25000	100	2700	15000	7	240	40	250	10	1	3	5	3	20	20	50	0.7	1.3	0.1	0.3
Root	50000	15000	1500	4200	5000	6	130	60	160	2	4	2	0.6	2	1	40	20	1	0.6	0.1	0.6
Pettibone Cr.	20000	15000	80	1500	2000	0.3	45	50	15	5	10	0.3	0.6	1	1	15	20	ND	0.4	0.1	0.2
Ind. Harb. Canal	15000	6000	30	1900	6000	3	150	400	130	4	2	0.9	0.1	3	2	90	20	ND	0.1	0.1	0.1
Burns Ditch	20000	15000	50	6250	7000	4	170	100	150	17	6	2	0.4	6	4	80	30	0.8	0.2	0.1	0.4
Trail Creek	2000	3000	50	8200	3000	2	75	50	40	0.2	1	0.6	0.1	1	1	2	15	ND	0.2	0.1	0.1
Lake Michigan (off Grand Haven)	9000	9000	10	500	3000	1	25	0.4	25	1.5	1	0.1	ND	0.8	1	3	--	ND	--	ND	ND
"Natural Water"[1]	6000	4000	400	6600	2000	1	100	7	20	1.0	0.6	0.3	--	--	2	7	20	0.2	3	--	0.04

[1]See Turekian, K. K. 1971.

TABLE 5.1-7

ORGANIC CONTAMINANT ANALYSES

LAKE MICHIGAN WATERS

DATE	SAMPLING SITE	COMPOUNDS FOUND AND CONCENTRATIONS		INFORMATION SOURCE
1968	8 km west of Ludington and 25 km west of Saugatuck	DDT, DDD, DDE, Dieldrin,	0.002 μg/L 0.001 μg/L 0.0005 μg/L 0.001 μg/L	129, 131
1971	open waters	PCBs,	<0.01 μg/L	131
	nearshore waters	PCBs,	<0.01 μg/L	
1972	0.5 km from shore			131
	16 samples	PCBs,	<0.01 μg/L	
	vicinity of:			
	- Ahnapee River	PCBs,	0.051 μg/L	
	- East Twin River	PCBs,	0.020 μg/L	
	- Menominee River	PCBs,	0.015 μg/L	
	- Oak Creek	PCBs,	0.027 μg/L	
	- Calumet River	PCBs,	0.056 μg/L	
	- Galien River	PCBs,	0.015 μg/L	
	- Paw Paw River	PCBs,	0.028 μg/L	
	- Pentwater River	PCBs,	0.012 μg/L	
1962-63	within Indiana Harbor	Phenols, average	33 μg/L	131
	Indiana Harbor Canal (12 samples)	Phenols, average	159 μg/L	
	Adjacent to Indiana Harbor	Phenols, average	3.1 μg/L	
1963	Mouth, Milwaukee River	Phenols, average	5-8 μg/L	131
1965	Indiana Harbor	Phenols, average	15 μg/L	131
	Chicago South Water Filtration Plant	Phenols, 20% samples	>3 μg/L	
1968	1033 inshore samples	Phenols, average	2 μg/L	131
1970-71	Kenosha to North Chicago - nearshore	Phenols, in 93% of 232 samples	<1 μg/L	131
1971	Chicago South Water Filtration Plant	Phenols, 11% samples	>3 μg/L	131
1976	Vicinity of Chicago (Lake Michigan)	PCBs	.04 μg/L	140
1976	Beaver Island	PCBs	.030 μg/L	140

TABLE 5.1-8

ORGANIC CONTAMINANT SURVEY OF LAKE MICHIGAN NEARSHORE WATERS[a]

ORGANICS SOUGHT AND ANALYTICAL DETECTION LIMITS (μg/L)

Aldrin:	0.01	Silvex:	1.0
Dieldrin:	0.02	Endrin:	0.02
o,p-DDT:	0.01	Heptachlor:	0.02
p,p-DDT:	0.01	Lindane:	0.05
Dibutyl phthalate (DBP):	1.0	Methoxychlor:	5
Diethylhexyl phthalate (DEHP):	1.0	PCBs:	0.3
Toxaphene:	1.0	Aroclor 1242:	0.1
Chlordane:	0.1	Aroclor 1254:	0.1
2,4-D:	5	Aroclor 1260:	0.1

SAMPLING DATES	NO. SAMPLES	SAMPLING SITE	ORGANICS IN EXCESS OF ABOVE DETECTION LIMITS, CONCENTRATIONS, AND DATES NOTED
1974-77	6	Grand River Mouth, Grand Haven, MI	none
1975-76	4	Water Intake, Holland, MI	DBP - 1.3 μg/L (01/76) DEHP - 1.5 μg/L (01/76)
1974-76	3	Manistee River Mouth, Manistee, MI	none
1974-76	5	Green Bay, Menominee, MI	none
1974-76	4	Muskegon River Mouth, Muskegon, MI	DEHP - 3.0 μg/L (05/74) - 2.4 μg/L (06/76)
1975-76	4	Water Intake, St. Joseph, MI	DEHP - 1.7 μg/L (07/76)
1976-77	4	Kalamazoo River Mouth Saugatuck, MI	none
1974-77	4	Boardman River Mouth Traverse City, MI	DEHP - 2.0 μg/L (07/74)

[a] Information provided by Michigan Department of Natural Resources

TABLE 5.1-9

ORGANIC CONTAMINANT CONCENTRATIONS IN WATERS OF TRIBUTARIES TO LAKE MICHIGAN[(a)]

ORGANICS SOUGHT AND ANALYTICAL DETECTION LIMITS (μg/L)

Dibutyl phthalate (DBP):	1.0	Endrin:	0.02
Diethylhexyl phthalate (DEHP):	1.0	Heptachlor:	0.02
Toxaphene:	1.0	Lindane:	0.05
Chlordane:	0.05	Methoxychlor:	0.05
2,4-D:	0.05	PCBs:	0.1
Silvex:	0.5	Dieldrin:	0.0001
DDT:	0.001	Aroclor 1254:	0.01

STATION	SAMPLING DATES	ORGANIC CONTAMINANTS FOUND, CONCENTRATIONS AND DATE
Grand River, Grand Rapid Waterworks	1975-76	DEHP - 1.5 μg/L (10/75)
Platte River, Homestead TWP	1972	DDT - 0.003 μg/L (11/72) Aroclor 1254 - 0.015 μg/L (11/72)
Platte River Inland TWP	1972	DDT - 0.001 μg/L (12/72)

(a) State of Michigan Department of Natural Resources

TABLE 5.1-10

SAMPLING SITES IN LAKE MICHIGAN "BASIN"

FOR STUDY BY EWING AND CHIAN (18)

Site Number	Site
1.	West Side Sewage Treatment Plant (effluent)
2.	Chicago Central water works (untreated and treated)
3.	Calumet - Sag Channel (midstream)
4.	Chicago Sanitary & Ship Channel
5.	North Side Sewage Treatment Plant (effluent)
6.	Calumet Sewage Treatment Plant (effluent)
7.	South West Filtration Plant (treated)
8.	Indiana Harbor
9.	Calumet River
10.	Grand River
11.	Cecil Bay
12.	Fox River, Green Bay
13.	Milwaukee River

NOTE: Within this study "the sites were chosen in such a way that the concentrations of organic and inorganic contaminants in the collected water samples would be affected by industrial pollutants and so that all principal types of industry would be represented."

Some of the sampling sites such as site #4 are not in the "Lake Michigan Basin." These sites are, however, at a very close proximity to the Basin, and compounds detected at these sites certainly have the potential to enter the Lake Michigan Basin. If the compounds are industrial pollutants, they may for example, be present in air emissions. Furthermore, most of the compounds identified within the Lake Michigan Basin (i.e. site #2), are found in sites near the boundary of the Basin (site #4).

TABLE 5.1-11

LIST OF VOLATILE COMPOUNDS OBSERVED IN 13 SITES
IN THE LAKE MICHIGAN BASIN

COMPOUND/SITE[a]	1	2	3	4	5	6	7	8	9	10	11	12	13
	Concentrations (μg/L)												
Acetone	1-2*	1-2	1-3	2-4	6	1			1				
Acetophenone		2				1		1					
Benzene	1-3	2-7	1-4	1-2	2	1	3	1	2				
Bromobenzene													3
1-bromo-1-chloroethane								1					
1-2-bromo-chloroethane								2					
Bromo-dichloromethane	1	2-9					4						
Butane			6										
Butene		1-2	1	1	3								
C_5H_8O or $C_6H_{12}O$						10							
$C_5H_{10}O$ or $C_6H_{12}O$						4							
Chlorobenzene		1-4	1	1	1		1		1				
Chloroform		5-30	5-30	2-20	1-100	20	8	1	1-12			3	1
Cyclopentane			4										
Dibromo-chloromethane		2-4				1							
Dibromoethane								4-10					
Dichlorobenzene			1	1									
1.2 Dichloroethane			1		1								
Dichloroethane	1-1			1	1				6				
Dichloroethylene		2	2	1	1	1			2				
Dichloromethane	1-8	2-30	1-2	2-8	15	3			1				
Dichloropropane	1-1				2								
Diethyl Ether	1	5	5	3	8	10							

TABLE 5.1-11 CONT'D

COMPOUND	Concentrations (μg/L) 1	2	3	4	5	6	7	8	9	10	11	12	13
Diisopropyl Ether				1									
Dioxane				1	1	1							
Ethylbenzene		4		1-2	1								
Fluro-dichloro-bromomethane		1											
Furfural		2											
Heptene								1					
Hexane		4-10	10	1-12	12								
Hexene Isomers								1					
Hexene		5		2	2				4				
Methyl ethyl dioxolane								1					
Methyl-isobutyl ketone				1				2					
Methyl methacrylate		10											
Methyl-tetrahydrofyran						2							
Neopentane								2					
Nonene		1											
Pentane		6-9	2-8	1-10	10	6			1				
Pentene Isomer				1-9									
Pentene				1	1								
Tetrachloroethylene	1-2	1	1-4	1-4	4	5		1	3				
Tetrahydrofuran	1	1	1	1	6	3							
Tetrahydropyran			2-3			9							
Toluene	2	1-5	1-2	1-2	2	1							
Trichloroethane	4	1	1	1	8	4		2	1				
1,1,1-Trichloroethane			3									1	
Trichloroethylene	4-5	2-10	1-5	4-6	10	4	2		6				
Trichloro-fluoromethane		3-4	6-12	20	20	5		1	1				
Trifluoro-trichloroethane			3	1	1								
Trichloro-trifluoroethane	5	2-30	3										

(a) see Table 5.1-10 for site designations.

*implies that acetone in concentrations between 1 and 2 μg/L was observed at site 1 (see Table 5.1-10, where site 1 is the West Side Sewage Treatment Plant)

TABLE 5.1-12

LIST OF ACID-EXTRACTABLE COMPOUNDS OBSERVED
IN 13 SITES IN THE LAKE MICHIGAN BASIN

COMPOUND SITE	Concentrations (μg/L) 1	2	3	4	5	6	7	8	9	10	11	12	13
C_9 Alcohol											1		
C_{10} Alcohol											1		
C_{11} Alcohol											1		
C_{12} Alcohol											4		
C_{13} Alcohol											3		
C_{14} Alcohol											3		
C_{15} Alcohol											2		
C_{16} Alcohol											2		
C_{17} Alcohol											1		
C_{18} Alcohol											1		
($C_{18}H_{12}$) Benzanthrene								1					
Butylbenzyl Phthalate		2		4									
Butyl Phthalyl Butyl Glycolate			48										
Camphor				8									
$C_{10}H_{10}$ Isomer			1										
$C_{16}H_{10}$ Isomer			1										
$C_{16}H_{10}$ (Pyrene)								1					
Dibutyl Phthalate	14		1										3
Diethyl Hexyl Phthalate	14-23	1-2	6-85	1-38	7	137	1	1	5				2
Fatty Acid Methyl Ester			5										
Fatty Acid Methyl Ester C = 12	10-22					4							
Fatty Acid Methyl Ester C ≥ 12				1									
Fatty Acid Methyl Ester C ≥ 13				1									
Fatty Acid Methyl Ester C = 14			7	1									
Fatty Acid Methyl Ester C ≥ 14	12		20-21	1-2		31		2					
Fatty Acid Methyl Ester C ≥ 14 + Methyl Pentachlorophenyl Ether	24(mix)		25(mix)										
Fatty Acid Methyl Ester C > 15	2												
Fatty Acid Methyl Ester C ≥ 15 + Methyl Pentachlorophenyl Ether	8(mix)												

TABLE 5.1-12 CONT'D

COMPOUND	Concentrations (μg/L) 1	2	3	4	5	6	7	8	9	10	11	12	13
Fatty Acid Methyl Ester C $\geq$ 16	4-12		3-9		7	19							
Fatty Acid Methyl Ester C $\geq$ 18	10		34		23								
Fatty Acid Methyl Ester C $\geq$ 19	4												
Fatty Acid Methyl Ester C $\geq$ 20	11-32	1	2-33	1-2	8								
Fatty Acid Methyl Ester C $\geq$ 21						4							
Fatty Acid Methyl Ester C $\geq$ 22	6-15	2		1-35									
Fatty Acid Methyl Ester C $\geq$ 22 + Methyl Dehydroabietate						90(mix)							
Fatty Acid Methyl Ester C $\geq$ 24		1	52	2-6									
Fatty Acid Methyl Ester C $\geq$ 26	2												
Hydrocarbon C $\geq$ 14			1										
Hydrocarbon C $\geq$ 16								2					
Hydrocarbon C $\geq$ 18				1				1-2					
Hydrocarbon C $\geq$ 18 + Methyl -2(4-chlorophenoxy) butanoate			10(mix)										
Hydrocarbon C $\geq$ 20				1									
Hydrocarbon C $\geq$ 22				1-18									
Hydrocarbon C $\geq$ 24				20									
Hydrocarbon C $\geq$ 30				20									
Methyl Arachidate	27					25							
Methyl-2(4-chlorophenoxy) Butanoate	11	1	10	1		4							
Methyl Dehydroabietate			4-37	15								1	
Methyl Dichlorophenyl Ether						5							
Methyl-2-ethyl hexanoate	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Methyl Myristate	9-24	1-2	2	2-5	6	18							
Methyl Palmitate	45-94	1-5	3-81	6-61	104	117	1	2-31		1		3	5
Methyl Pentachlorophenyl Ether		3	43	1-10		26							
Methyl Stearate	43-131	1-11	3-79	8-56	180	173		2-5	1	1			6
Methyl Tetrachlorophenyl Ether	5												
Methyl Trichlorophenyl Ether	1-14		12			10							
C_{15} Terpene												1-2	
C_{10} Terpineol		1	10	7		15							
C_{15} Terpineol	6-21		104	8-9	8		1		4				

TABLE 5.1-13

LIST OF BASE-EXTRACTABLE COMPOUNDS OBSERVED IN THE LAKE MICHIGAN BASIN

COMPOUND	Concentrations (µg/L) 1	2	3	4	5	6	7	8	9	10	11	12	13
Alkyl Acid Ester ($R + R^1 \geq 8$)				1		2							
Benzylbutyl Phthalate								1					
Butyl Phthalyl Butyl Glycolate				3									
Caffeine			1-2	4		1		2					
Camphor	TR	TR	TR	TR				TR	TR		TR	TR	TR
$C_{16}H_{10}$ (Pyrene)								1					
$C_{18}H_{12}$			1										
Dibromo-chloroethane	14												
Dibromoethane								6					
Dibutyl Phthalate	1	1	1	4				1					
Dichlorobenzene			4-18	1		16							
Dichlorobenzene Isomer				1									
Dichlorobutane													2
Diethoxyethane			3	4-5				4					
1-2 Diethoxyethane		2											
Diethyl Hexyl Phthalate	1		1-7	1-3		1		2-4			1	1	1
Diethyl Phthalate		4											
Diisobutyl Phthalate	1												
Dimethyl Biphenyl			1										
Hydrocarbon $C \geq 16$			1					1					
Hydrocarbon $C \geq 18$								1					
Hydrocarbon $C \geq 22$				1				1					
Hydrocarbon $C \geq 24$				1									
Hydrocarbon $C \geq 28$								1					
Naphthalene (IS)	TR	TR	TR	TR	TR	TR	TR	TR	TR				
Terpineol	1	2	1	1-4				4					
Terpineol C_{10}		3	1	1-2									
Terpeneol C_{15}			1	2-3	1								
Tetrachloroethane		2											
Tetrachloroethylene			2-11.3	2-3									
Unidentified Phthalate				3									
Xylene	19												

5.2 Data on Sediment Quality

Heavy Metals

Table 5.2-1 summarizes data on heavy metal concentrations in Lake Michigan sediments. The initial data in the table was obtained from the Argonne National Laboratory publication on the chemistry of Lake Michigan (131). In addition, the results of EPA's Lake Michigan Harbor Sampling Program (141) and the Michigan Department of Natural Resources studies on sediment quality (142) are included. Table 5.2-2 shows the harbors in Lake Michigan which have been designated by U.S. EPA Region V as heavily polluted (143). Sediments designated as such by Region V, if dredged, generally cannot be disposed in the open waters of the lake.

Fitchko and Hutchinson (31) analyzed the heavy metal concentrations in outlets sediments of Lake Michigan tributaries and the results are shown in Table 5.2-3. The PLUARG studies have evaluated the metal concentrations in soils and bottom and suspended sediments in the Menomonee River watershed (144), and the results are given in Table 5.2-4. Leland (134) evaluated the composition of suspended matter in offshore waters of Lake Michigan (Table 5.2-5).

Organic Contaminants

Concentrations of organic compounds found in Lake Michigan sediments are shown in Table 5.2-6 to 5.2-8. PCBs, dieldrin and DDT have been detected, with high concentrations (>1 ppm) of PCBs detected at the Manistique River Harbor (145), the mouth of the Escanaba River (145), Fox River (127) and Milwaukee Harbor (127). PLUARG in 1978 estimated the average lakewide PCB concentration to be 38.2μg/kg (9).

A special study by the U.S. FDA (158) indicated high levels of PCBs and Pydraul 50E (a substitute for PCBs) in a sediment sample collected in the vicinity of the Outboard Marine Co. outfall in Waukegan Harbor.

Table 5.2-9 shows the results of a study (168) which attempted to evaluate the relationship between organic carbon and trace elements in Lake Michigan sediments.

TABLE 5.2-1

SUMMARY OF DATA ON HEAVY METAL CONCENTRATIONS
IN LAKE MICHIGAN SEDIMENTS

SAMPLE DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	CONCENTRATION - ppm dry weight									INFORMATION SOURCE
			MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	OTHER	
1970	Southeast Basin (surficial sediments)						19					131
1972	Southwest Basin (surficial sediments)						7					131
1972	Lakewide						N.D.-6					131
1972	Green Bay							1-5				131
1972	Southwest Basin							5-15				131
1971	Southern Basin (surficial sediments)									6-80		168
1974	Southern Basin (background)			23								131
1971	Southern Basin >15 cm depth		.03-.06									131
1972	Green Bay (selenium)										.5-4.9	131
1972	Lakewide (silver) 11 samples 8 samples										 N.D. .2-1.3	131
1971	Southwest Basin (Brown silt facies) (top 2-3 cm)				123 (31-282)							131
1971	Southwest Basin (Gray Silt facies) (top 2-3 cm)				231 (31-282)							131
1970	Southern Basin (See Table 5.2-9)	21		✓	✓	✓			✓	✓	✓	167
1970	Southern Basin (See Table 5.2-10)	19					✓					168

TABLE 5.2-1 CONT'D

LAKE MICHIGAN SEDIMENTS - METAL ANALYSES

DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	CONCENTRATION - ppm dry weight								INFORMATION SOURCE
			MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	
1974	Manistee Harbor	6	<.1	14-58	9-47	11-35	<1	3-6	<2-11	1-19	141
1974	Muskegon Harbor	4	<.1	19-36	6-9	13-17	<2	<.2-1	<2	<1-4	141
1974	Pentwater Harbor	4	<.1	22-60	8-12	12-27	<1	<.2-4	<2	<1-10	141
1976	Vicinity - Galien River,*										
	2.5-15 m (depth)	4	<.01-.03	3-7	7-18	5-9	-	<.1	1-2	7-1.2	142
	20 m	3	.01-.03	14-16	43-54	9-10		<.1-.2.	4-5	2-3	
1976	Vicinity - South Haven*										
	4-15 m	4	<.01-.02	5-7	11-15	6-8	-	<.1	2-3	1-2	142
	30 m	3	5-7	8-25	51-59	6-9	-	.4-.7	6-9	5-7	
	54 m	3	40-50	42-130	190-240	32-39	-	1.2-1.8	32-40	40-50	
1976	Vicinity - St. Joseph River*										
	6-15 m	4	<.01-.03	2-3	8-16	4-6	-	<.1	1-3	1-2	142
	30 m	3	.05-.06	32-33	120-130	14-15	-	.4-.5	16-18	14-15	
1976	Vicinity Kalamazoo River*										
	5-15 m	4	<.01-.03	3-4	8-12	4-5	-	<.1	2	.8-1	142
	30 m	3	.02-.06	16-34	46-70	7-12	-	.3-.5	8-12	6-9	
1976	Vicinity - Grand River*										
	7-16 m	4	<.01-.01	2-3	8-10	4-5	-	<.1	2	.7-1.2	142
	30 m	3	.04-.06	35-37	56-67	16-18		.6-.8	10-14	8-9	

TABLE 5.2-1 CONT'D

LAKE MICHIGAN SEDIMENTS - METAL ANALYSES

DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITES	CONCENTRATION - ppm dry weight								INFORMATION SOURCE
			MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	
1976	Vicinity - Muskegon Lake*										142
	7-15 m	4	<.01-.03	2-3	7-9	4	-	<.1	2	.5-.8	
	30 m	3	.01-.03	35-46	57-64	20-22	-	.6-.8	9-10	7-8	
1976	Vicinity - White Lake*										142
	7-15 m	4	.01-.04	2	6	3-4		<.1	2	.6-.7	
	30 m	3	<.01-.03	16-18	30-36	8-11	-	<.1-.3	5	4	
1976	Vicinity - Lake Macatawa*										142
	7-15 m	4	.01-.03	2-4	7-12	5-7	-	<.1	2-3	.5-1	
	33 m	3	.05-.06	28-29	44-46	16-20	-	.4-.7	8	6-7	
1976	Vicinity - Pere Marquette River*										
	8-28 m	7	<.01-.02	1-5	5-12	2-6		<.1	1-2	.3-3	142
1976	Vicinity Betsie Lake*										142
	8-30 m	7	<.01-.02	.4-3	3-7	2-5		<.1	1-2	.4-1.2	
	45 m	3	<.01-.01	3-12	8-19	4-8		<.1	2-3	2-3	
1976	Vicinity - Manistee River*										142
	8-15 m	4	<.01-.05	.2-2	3-4	2-4	-	<.1-.3	.2-1.3	.3-.9	
	31 m	3	.03-.07	7-10	10-17	4-6	-	<.1	2-3	2	
1976	Vicinity - Naubinway Control*										142
	8-18 m	6	<.01-.01	7-12	11-31	5-13		<.1-.3	2-7	2-4	
	location @ 18 m	1	.01	21	110	23		<.1	12	11	

TABLE 5.2-1 CONT'D

LAKE MICHIGAN SEDIMENTS - METAL ANALYSES

DATE	SAMPLING STATION OR DESIGNATION	NUMBER SAMPLING SITE	CONCENTRATION - ppm dry weight								INFORMATION SOURCE
			MERCURY	LEAD	ZINC	NICKEL	ARSENIC	CADMIUM	CHROMIUM	COPPER	
1976	Vicinity - Manistique River*										
	6 m	4	.01-.06	6-46	10-66	3-18		<.1-1	2-8	2-4	142
	15-34 m	6	<.01-.02	<.2-4	2-10	<1-4	-	<.1-.7	.4-1	.1-.9	
1976	Vicinity - Menominee River*										
	6-17 m	4	.01-.09	3-12	15-32	6-12	-	<.1-.5	3-5	2-7	142
	34 m	3	.03-.07	13-24	38-110	22-140	-	.5-4	8-15	9-14	
1976	Vicinity - Escanaba River*										
	6 m	1	.2	9	38	7	-	<.1	4	7	142
	15 m	3	.1-.2	110-190	260-350	36-65	-	2-3	35-52	48-71	
	26 m	3	.01-.03	4-12	10-22	3-9	-	<.1-.4	3-10	2-8	
1976	Vicinity - Cedar River*										
	Big Bay, DeNoc										
	6-17 m	4	.01-.04	9-130	10-79	5-24	-	.2-1.1	4-13	2-6	142
	29 m	3	.03-.05	13-20	88-110	54-110	-	1-3	12-21	11-14	

* refers to depth of water column above sediment.

TABLE 5.2-2

U.S. EPA REGION V ANALYSES OF SEDIMENTS
IN LAKE MICHIGAN HARBORS

Harbor/Year Sampled	TOTAL PCBs (mg/kg dry weight) LOW	HIGH
Waukegan, IL/1976	0.1	16,400
Pensaukee, WI/1977	<2	<2
Port Washington, WS/1977	<2	<2
Indiana Harbor, IN/1977	.04	25.7
Holland, MI/1977	<.01	.62
New Buffalo, MI/1977	<.01	.10
Sheboygan, WS/1977 (outer harbor)	.06	.32
Fox River, WS/1977	.67	11.56
Algoma, WS/1977	<.02	.84
Kenosha, WS/1977	.07	.71

Harbor (Designated Heavily Polluted re: Hg)	Mercury (mg/kg) (1975-76)	# Values (a) >1 mg/kg
Great Lakes Training Base, IL	2-14	5

Harbor (Designated Heavily Polluted re: Cd)	Cadmium (mg/kg) (1975-76)	# Values >6 mg/kg
Michigan City, IN	6.3-81.0	11
St. Joseph, MI	7-10	6
Marinette, WI: Menominee, MI	9	1
Great Lakes Training Base, IL	31	1

Harbor (Designated Heavily Polluted re: As)	Arsenic (mg/kg) (1975-76)	# Values >8 mg/kg
Michigan City, IN	9-14	7
Calumet Harbor, IL	9-23	7
Great Lakes Training Base, IL	11-120	6
Marinette, WI - Menominee, MI	10-87	3
Burns Water, IN	10-12	3
St. Joseph, MI	12	1

TABLE 5.2-2 CONT'D

Harbor (Designated Heavily Polluted re: Pb)	Lead (mg/kg) (1975-76	# Values >60 mg/kg
Calumet Harbor, IL	65-280	13
Michigan City, IN	90-360	11
St. Joseph, MI	65-190	9
Manitowoc, WI	63-269	9
Great Lakes Training Base, IL	136-375	8
Two Rivers, WI	85-200	6
Sheboygan, WI	115-220	4
Port Washington, WI	62-68	3
Frankfort, MI	66-68	2
Sturgeon Bay, WI	95-110	2
Ludington, MI	62	1
Kewaunee, WI	70	1
Marinette, WI: Menominee, MI	74	1

a) number of samples within which quantities were greater than the value indicated. The total number of samples were not reported.

TABLE 5.2-3

Concentration of heavy metals in outlet sediments of Lake Michigan tributaries.

Site	Concentration (ppm)									(ppb)
	Pb	Ag	Cd	Co	Cu	Cr	Ni	Zn	Mn	Hg
Bear River	22.1	0.7	1.0	9.2	6.1	2.5	8.7	21.2	34	40
Lake Charlesvoix Outlet	4.5	0.2	0.4	5.2	2.0	T	2.3	2.5	13	<10
Carp River	14.2	0.4	0.7	8.3	2.8	1.4	6.4	6.3	27	30
Betsie Lake Outlet	7.3	0.2	0.3	5.2	3.1	0.7	3.4	10.0	49	20
Manistee Lake Outlet	2.5	0.2	0.2	3.6	1.0	T	1.9	3.5	26	10
Pere Marquette Lake Outlet	5.3	0.2	0.3	4.2	1.5	1.7	3.3	7.8	42	30
Pentwater Lake Outlet	1.7	0.1	0.1	2.5	0.6	T	1.9	4.0	21	10
Muskegon Lake Outlet	1.3	T	T	1.8	0.5	T	1.6	4.0	16	10
Muskegon Lake (Upstream)	81.5*	0.5	1.8*	6.8	26.5*	149.4**	11.5	135.0*	93	310*
Grand River	66.5*	0.8*	3.5*	14.1	84.0*	662.0**	74.8*	398.0*	308	320*
Lake Macatawa Outlet	2.5	0.1	0.2	3.7	0.9	0.5	2.6	5.0	35	<10
Kalamazoo River	2.5	0.1	0.2	3.3	0.5	T	2.0	5.3	35	<10
Black River	5.8	0.2	0.4	5.4	1.8	1.5	4.2	10.3	59	70
Black River (Upstream)	32.5*	0.5	0.9	11.8	18.0	22.9*	17.5	100.0	338	160*
St. Joseph River	3.3	0.2	0.3	4.6	1.2	0.5	2.8	5.3	40	30
St. Joseph River (Upstream)	38.5*	0.3	0.7	4.3	6.3	6.3	6.0	40.0	38	90
Trail Creek	5.7	0.2	0.4	4.8	1.9	0.8	3.3	13.0	44	20
Calumet River	86.0*	0.9*	1.8*	20.6*	30.9*	20.5*	18.1	248.0*	457*	150*
Root River	97.0*	0.7	1.4	15.3	31.5*	21.7*	15.1	104.2	277	240*
Milwaukee River	149.0**	1.0*	16.6**	18.0*	73.4*	1295.0**	25.4	295.5*	251	1200**
Sauk Creek	39.1*	1.0*	1.8*	11.7	24.2*	28.7*	13.5	48.7	126	120*
Sheboygan River	41.5*	0.7	1.4	10.3	16.8	32.9*	15.1	40.3	95	60
Manitowoc River	22.8	0.6	1.6	9.5	10.1	13.7	10.9	35.0	92	80
Twin Rivers	30.4	0.4	2.8*	8.9	12.5	10.8	13.2	61.2	97	120*
Kewaunee River	16.0	0.7	1.2	9.9	5.0	3.9	9.4	12.3	60	60
Ahnapee River	14.5	0.5	0.8	7.0	3.8	3.0	5.7	13.2	30	50
Menominee River	19.7	0.3	1.1	8.0	11.8	4.9	9.5	54.2	194	280*

*Signifies elevated concentration
**Signifies excessive concentration

Table 5.2-4 Metal* concentrations in various size fractions of soils and bottom and suspended sediments in the Menomonee River watershed

(Ref. 144)

Sample/sample location**	Metal, µg/g								
	Pb			Cd			Cu		
	Sand	Silt	Clay	Sand	Silt	Clay	Sand	Silt	Clay
					SOILS***				
Ozaukee silt loam	n.d.	9.5	58	n.d.	0.16	0.78	2.3	17	90
Mequon silt loam	4.7	11	39	n.d.	0.25	0.73	4.0	15	82
Hochheim silt loam	5.5	9.8	56	n.d.	0.11	0.35	1.8	7.3	41
Ashkum silty clay loam	9.0	14	36	n.d.	0.53	1.24	2.0	27	106
Pella silt loam	9.8	10	39	n.d.	0.23	0.81	1.9	8.2	44
Theresa silt loam	n.d.	6.0	55	n.d.	0.12	0.44	2.1	4.8	36
					BOTTOM SEDIMENT				
Upper Menomonee River									
Friestad	4.1	7.8	25	n.d.	0.20	1.3	2.1	9.8	52
River Lane (673001)	7.4	16	41	n.d.	n.d.	0.98	1.9	8.2	44
Menomonee Falls	12	18	55	n.d.	n.d.	0.54	3.6	7.1	38
Northern Crossway	32	101	512	0.08	0.72	3.2	4.1	27	149
Lily Creek	36	64	438	n.d.	0.31	2.9	9.4	11.8	145
Dretzka Creek	17	55	334	0.11	0.59	2.5	4.1	20	122
124th St (683001)	14	33	208	n.d.	0.26	1.7	6.7	17	85
Little Menomonee River									
Donges Bay Road (463001)	2.5	7.3	36	0.06	0.21	1.1	2.4	8.5	48
County Q Road	9.6	17	25	n.d.	n.d.	0.86	2.8	11	36
Road F near Road B	4.1	16	65	0.06	0.45	1.6	1.7	8.1	48
Appleton Ave (413008)	20	21	41	n.d.	0.16	0.58	3.0	6.6	29
Lower Menomonee River									
Capitol Drive	32	35	115	0.19	0.44	1.8	6.6	13.8	108
70th St (413005)	16	92	487	0.07	0.52	3.8	5.7	42	110
Falk Corporation (413004)	170	412	1,439	1.88	4.98	33	102	219	475
					SUSPENDED SEDIMENT				
Upper Menomonee River									
River Lane (673001)	n.a.	n.d.	83	n.a.	n.d.	2.4	n.a.	29	37
Pilgrim Road (683002)	n.a.	50	244	n.a.	n.d.	n.d.	n.a.	22	51
124th St (683001)	n.a.	60	204	n.a.	n.d.	0.90	n.a.	19	71
Little Menomonee River									
Donges Bay Road (463001)	n.a.	n.d.	43	n.a.	n.d.	0.34	n.a.	20	47
Noyes Creek (413011)	n.a.	139	166	n.a.	n.d.	0.58	n.a.	41	41
Appleton Ave (413008)	n.a.	31	63	n.a.	n.d.	0.37	n.a.	8.3	38
Lower Menomonee River									
Underwood Creek (413007)	n.a.	348	515	n.a.	n.d.	1.7	n.a.	40	78
Honey Creek (413006)	n.a.	158	333	n.a.	0.81	1.4	n.a.	39	76
70th St (413005)	n.a.	125	165	n.a.	n.d.	0.88	n.a.	50	70
Schoonmaker Creek (413010)	n.a.	967	1,513	n.a.	n.d.	4.4	n.a.	50	104
Falk Corporation (413004)	n.a.	104	118	n.a.	0.77	0.75	n.a.	37	69

*Samples have been analyzed for Zn, Fe, Cr, Ni and Mn

**STORET numbers of major monitoring stations in parentheses

***Approximately 100 soil types have been mapped in the Menomonee River watershed. Total area of the watershed is 35,285 ha of which 26,712 ha are mapped by soil type. The soils listed constitute 70% of the total area mapped as soil.

n.d. Not detected

n.a. Sand fraction not present

TABLE 5.2-5

(Ref. 134)

Elemental composition of suspended matter in offshore waters of Lake Michigan (July 1972).

	Southern Basin						Northern Basin*	
	Epilimnion (5-7 Metres)			One Metre Above Lake Floor				
Trace Element (µg per g)	Mean	Range	Number of Samples	Mean	Range	Number of Samples	Epilimnion (7 metres)	One Metre Above Lake Floor
As	40.	9-61	14	27.	8-42	12	25.	15.
B	96.	30-160	14	250.	150-380	9	150.	240.
Be	0.7	0.6-0.9	3	1.2	1.0-1.7	9	0.9	2.5
Br	15.	12-20	14	9.7	2-19	12	11.	11.
Co	8.	3-13	3				9.	11.
Cr	54.	33-79	6	98.	64-160	8	66.	104.
Cu	101.	21-230	14	39.	17-102	12	300.	170.
Mo							4.7	1.6
Ni	33.	7-50	14	47.	26-84	12	38.	42.
Pb	51.	8-73	14	56.	39-97	12	230.	120.
Sn							9.8	18.
Sr							113.	88.
V	69.	15-180	14	56.	26-72	12	120.	120.
Zn							400.	250.

*Concentrations in northern basin are for one composite sample of suspended matter from eight off-shore locations.

TABLE 5.2-6

GENERAL SURVEY OF ORGANIC CONTAMINANT CONCENTRATIONS IN SEDIMENTS OF LAKE MICHIGAN

LOCATION AND DATE	CONTAMINANTS AND CONCENTRATIONS		SOURCE
Southern Basin	ΣDDT - surface sediments	18.5 μg/kg	131
	- 2-6 cm	6.3 μg/kg	
	- 6-12 cm	3.4 μg/kg	
	Dieldrin - surface sediments	2.0 μg/kg	
	- 2-12	<0.5 μg/kg	
Waukegon to Evanston 11 stations (1973)	ΣDDT	2.9 μg/kg	131
	Dieldrin	0.1 μg/kg	
Loyola University to Jackson Park - Chicago 8 stations (1973)	ΣDDT	14.4 μg/kg	131
	Dieldrin	0.8 μg/kg	
Vicinity of 5 WWTP plants between Waukegon and Highland Park (1974)	Aroclor 1242	.01-.11 μg/kg	131
	Aroclor 1254	.01-.03 μg/kg	
Waukegon to Jackson Park, Chicago, 19 samples (1974)	Aroclor 1242	N.D.-.08 μg/kg	131
	Aroclor 1254	.002-.05 μg/kg	
Lake wide average (reported 1978)	PCB	38.2 μg/kg	9
Waukegon Harbor	PCB (as Arochlor 1248)	5%	158
	Pydraul 50 E*	.8%	

*Consists of triphenyl phosphate, diphenylnonylphenyl phosphate and diphenylcumylphenyl phosphate.

TABLE 5.2-7

ORGANIC CONTAMINANT CONCENTRATIONS IN SEDIMENTS OF LAKE MICHIGAN[a] (1976)

ORGANIC CONTAMINANTS SOUGHT AND ANALYTICAL DETECTION LEVELS (μg/kg)

Dieldrin:	5	HCB:	2
Chlordane:	20	HCBD:	2
DDD:	10	Aroclor 1254:	500
DDE:	4	Aroclor 1260:	500
o,p-DDT:	5	Aroclor 1242:	500
p,p-DDT:	5		

STATION (vicinity of)	ORGANIC CONTAMINANTS FOUND IN EXCESS OF DETECTION LEVELS AND CONCENTRATIONS
Galien River	none
St. Joseph River	Dieldrin - <10 μg/kg at 30 meters (m) DDE - <10 μg/kg at 30 m HCB - < 5 μg/kg at 30 m HCBD - < 5 μg/kg at 30 m
South Haven	HCB - < 5 μg/kg at 45 m HCBD - < 5 μg/kg at 45 m
Kalamazoo River	none
Holland	p,p-DDT - 5.9 μg/kg at 15 m 7.1, 5.6 μg/kg at 30 m
White River	p,p-DDT - 7.4 μg/kg at 30 m
Pere Marquette River	none
Manistee River	none
Betsie Lake	none
Naubinway Control	none
Manistique River	none
Manistique River Harbor	Aroclor 1242 - 5.1 mg/kg, 2.6 mg/kg, 17.5 mg/kg Aroclor 1254 - 5.1 mg/kg, 0.6 mg/kg, 7.8 mg/kg
Escanaba River	none
Escanaba River Mouth	Aroclor 1254 - 1.6 mg/kg
Cedar River	none
Menominee River	none

(a) State of Michigan Department of Natural Resources

TABLE 5.2-8

Concentrations of PCBs in Lake, Streams and Harbor Sediments in Wisconsin (127)

Sample Location	Testing Laboratory (Number of Samples)	Sediment Concentration ppb (Aroclor)
East end of Sturgeon Bay Bouy #12	DNR (1)	20
Coast Guard Winter Dock in Sturgeon Bay	DNR (1)	140(1254)
West End of Sturgeon Bay Bouy #22	DNR (1)	90(1248)
Fox River at Portage WWTP Outfall	DNR (1)	72,000(1242)
Fox River at Columbia County Highway 0 between U.S. 51 & 22	DNR (1)	230(1242)
Lower Green Bay East of the Mouth of the Fox River	Envirex, Inc. (5) *	180(1242) 13(1254)
Milwaukee Harbor	Envirex, Inc. **	6,420
Lake Pepin	U.S. Environmental *** Protection Agency (9)	266

* Taken in upper layer of core sediment

** Upper foot of sediment

*** Average of nine sampling stations in Lake Pepin

Table 5.2-9 —AVERAGE CONCENTRATIONS OF TRACE ELEMENTS, IRON OXIDE, ORGANIC CARBON, AND LESS THAN 2-MICRON CLAY IN SOUTHERN LAKE MICHIGAN CORES

Constituent	Top interval*		1 - 7 cm		4 - 12 cm		8 - 20 cm		16 cm and deeper	
Br (ppm)	65 ± 38	(17)†	60 ± 29	(12)	47 ± 21	(18)	48 ± 24	(17)	35 —	(19)
Cr (ppm)	70 ± 30	(22)	66 ± 22	(15)	57 ± 20	(21)	55 ± 16	(19)	52 —	(24)
Cu (ppm)	41 ± 24	(22)	33 ± 14	(15)	28 ± 10	(21)	27 ± 9	(19)	20 ± 9	(24)
Pb (ppm)	79 ± 54	(22)	65 ± 45	(15)	44 ± 37	(21)	30 ± 18	(19)	20 ± 3	(23)
Zn (ppm)	179 ± 125	(22)	148 ± 107	(15)	115 ± 71	(21)	86 ± 38	(19)	66 ± 12	(23)
Ni (ppm)	34 ± 12	(22)	32 ± 8	(15)	34 ± 8	(21)	33 ± 11	(19)	35 ± 6	(23)
MnO (%)	0.065 ± 0.033	(22)	0.070 ± 0.022	(15)	0.067 ± 0.023	(21)	0.057 ± 0.023	(19)	0.050 ± 0.018	(24)
Fe_2O_3 (%)	3.99 ± 1.28	(22)	3.91 ± 1.02	(15)	3.81 ± 1.03	(21)	3.54 ± 1.17	(19)	3.35 ± 0.65	(24)
Organic carbon (%)	2.35 ± 1.44	(22)	2.03 ± 1.20	(15)	1.85 ± 0.95	(21)	1.88 ± 1.04	(19)	1.40 ± 0.48	(23)
< 2μ clay (%)	31.6 ± 19.3	(20)	29.7 ± 13.6	(14)	34.5 ± 10.8	(19)	34.3 ± 15.6	(18)	41.4 ± 8.8	(24)

* Values given for each interval are, in order, average trace element concentration, standard deviation, and number of samples used to compute the mean.

† Numbers enclosed in parentheses equal number of samples used in calculating the correlation coefficient.

5.3 DATA ON AIR QUALITY AND PRECIPITATION

Tables 5.3-1 and 5.3-2 summarizes the units of analyses of rain, snow and air from the Lake Michigan Basin. Studies by Murphy (102, 140) and, Andren and Doskey (146) have been directed to the quantification of atmospheric inputs of PCBs to Lake Michigan in particular.

Loading estimates of metals were reported by: PLUARG (47) in its report on "Atmospheric Loadings of the Lower Great Lakes and the Great Lakes Drainage Basin"; Konrad, Chesters and Bauer (144) to evaluate atmospheric loading to the Menomonee River watershed; and, Eisenreich (147) and Schmidt (148) at the 1978 Conference on Great Lakes Research. The results of the above noted studies are given in Tables 5.3-1 and 5.3-2. Additional results from reference 47, are shown in Tables 5.3-3 and 5.3-4.

Volume 8 of the Argonne Laboratory report series on the "Environmental Status of the Lake Michigan Region," entitled "Atmospheric Environment of the Lake Michigan Drainage Basin" provides a thorough review of atmospheric inputs of the elements to Lake Michigan (149). Much data is provided in the report such as identification of sampling sites, meteorological influences, etc. Tables 5.3-4 and 5.3-5 are examples of the information contained within the report.

TABLE 5.3-1

ANALYSES OF THE ATMOSPHERE AND PRECIPITATION IN THE LAKE MICHIGAN BASIN

Date	Sampling Site	Sample	No. Samples	Experimental Results	Source
1975-77	Chicago (DePaul University)	Rain	31	PCBs-(Arith. mean-193 ng/L) (% dissolved -66)	102, 140
1975-77	Chicago (DePaul University)	Snow	4	PCBs (Arith. mean-212 ng/L) (% dissolved -36)	102, 140
1975-77	Chicago (DePaul University)	Air	4	PCBs (Arith. mean-7.6 ng/m^3 (% in filtered portion-97)	102, 140
1976	Beaver Island	Rain	13	PCBs (Arith.mean-215 ng/L) (% dissolved-53)	102
1976	Mammoth Cave National Park	Air	1	PCBs -6.7 ng/m^3 (% in filtered portion-95)	102
1976	Landfill Gases		2	PCBs - 3240 ng/m^3	102
1976	Chicago Area	Rain	5	PCBs - 97.5 ng/L	112
	Beaver Island	Rain	1	PCBs - 229 ng/L	112
1976	Menominee River Watershed	Rain		Pb - 32 ppb* Cd - 3.74 ppb	144
1977	Open waters	Air	1	PCBs-Filtered extract-.12 ng/m^3 (76% - 1242 : 24% - 1254)	146
			1	PCBs Vapor state - 1.4 ng/m^3 (70%- Aroclor 1242: 30% Aroclor 1254)	
			1	PCBs Total - 0.66 ng/m^3	
			1	PCBs Total - 0.14 ng/m3	

*Calculated loading - by rainfall - 230 g/ha/yr.
- by dry deposition - 180 g/ha/yr.

Total loading of lead to watershed by atmosphere - 1.4 x 10^4 kg/yr.

TABLE 5.3-2

ATMOSPHERIC LOADING ESTIMATES - LAKE MICHIGAN

PARAMETER	SEE NOTE	ACRES (47)	EISENREICH (147)	SCHMIDT (148)
		10^6 kg/Year		
SO_4	MM	330		
	PC	NA		
N	MM	42		
	PC	NA		
PART.	MM	56		
	PC	NA		
		10^3 kg/Year		
TP	MM	350		
	PC	1000*		
Ca	MM	1800		
	PC	NA	84,000	
Mg	MM	810		
	PC	NA	16,900	
Na	MM	500		
	PC	NA	12,000	
K	MM	1500		
	PC	NA	6,800	
Cd	MM	48		
	PC	NA		
Pb	MM	1100		
	PC		800	1350-2500
Ni	MM	71		
	PC	NA		
Cu	MM	55		
	PC	NA	130	310-550
Fe	MM	5500		
	PC	NA	3,210	
Cr	PC			200-360

NOTE

MM - Mathematical Model
PC - Precipitation Chemistry
NA - Not available

* U.S. EPA 1975

TABLE 5.3-3

SOURCE	LAKE MICHIGAN NORTH	SOUTH	TOTAL
CHICAGO	12.7	31.1	24.5
SAGINAW	6.8	3.1	4.5
DETROIT	5.1	3.4	4.0
GREEN BAY	7.8	2.9	4.7
DULUTH	1.3	.6	.9
MINNEAPOLIS	2.3	1.7	1.9
WISCONSIN	2.4	.6	1.2
MILWAUKEE	5.1	6.5	5.9
ILLINOIS-IOWA	3.8	3.8	3.8
ST. LOUIS	7.6	9.3	8.6
INDIANA - CINCINNATI	12.2	16.7	15.2
MICHIGAN	7.1	1.4	3.5
TOLEDO	4.9	2.7	3.5
CLEVELAND	3.6	3.4	3.5
OHIO	4.9	5.5	5.3
PITTSBURGH	3.6	3.0	3.2
PENNSYLVANIA	2.3	1.8	2.0
WESTERN NEW YORK	.2	.3	2
ROCHESTER	.3	.3	.3
BUFFALO	.3	.2	.2
AMERICAN TOTAL	94.3	98.3	96.9
TORONTO	.4	.3	.3
SUDBURY	.6	.1	.3
THUNDER BAY	.4	.1	.2
SAULT ST. MARIE	2.6	.3	1.2
MONTREAL	.1	.3	.2
SARNIA	.1	.1	.1
NORTHERN ONTARIO	.4	.1	.2
SOUTHERN ONTARIO	.5	.3	.3
NORANDA	.2	<.1	.1
MANITOBA	.4	.1	.2
CANADIAN TOTAL	5.7	1.7	3.1

NOTE LOADINGS ARE PRESENTED AS PERCENTAGE OF THE FOLLOWING TOTAL LOADINGS (10^3 kg PER YEAR): NORTH 2500, SOUTH 4300, TOTAL 6800

CONSTITUENT	Fe	Pb	Ni	Cu	Cd
% OF TOTAL	80.9	16.6	1.0	.8	.7

TRANSBOUNDARY LOADING OF TRACE METALS

Table 5.3-4 Trace Element Concentrations ($\mu g/m^3$) in Chicago Aerosols (Modified from Gatz, 1975)

	Source of Data and Period of Sampling							
	Harrison and Winchester	*Brar et al.*	*National Air Surveillance Network*				*Chicago Air Sampling Network*	
Element	*1968*	*1968*	*1966*	*1967*	*1968*	*1969*	*1970-1971*	*Composite Model**
Al		1.5						(1.5)
As							0.017[a]	0.02
Cd	0.015		0.03	0.01	0.008	0.015		0.01
Cr		0.018	0.008	0.005	0.023	0.016		0.02
Cu	0.182		0.08	0.09	0.13	0.12	0.14	0.14
Fe		2.6	2.4	2.7	4.3	4.0	3.3	3.5
Mn		0.45	0.08	0.08	0.09	0.12	0.10	0.10
Ni			0.029	0.031	0.033	0.051		0.04
Pb	2.5		1.6	1.2	1.6	1.6	1.2	1.2
Ti			0.01	0.02		0.02		(0.2)[b]
V		0.024	0.048	0.059		0.096		0.08
Zn		0.062	1.7	1.1			0.65	(0.3)[b]

**Parentheses indicate considerable uncertainty in model concentrations due to limited number of measurements.*

[a]*Arsenic measured September to December, 1971, only.*

[b]*Estimated from St. Louis data of Gatz (1974). National Air Surveillance Network data for these elements are not reliable (Winchester, 1975--personal communication; Akland, 1975--personal communication).*

References: Harrison and Winchester (1971); Brar et al. (1970); National Air Surveillance Network--EPA (1972, 1973a); Chicago Air Sampling Network--Chicago Dep. Air Pollut. Control, 1971).

Table 5.3-5 Trace Element Concentrations ($\mu g/m^3$) in Northwest Indiana Aerosols (Modified from Gatz, 1975)

	Source of Data and Period of Sampling										
			National Air Surveillance Network								
	Harrison and Winchester	*Harrison et al.*	*Hammond*				*East Chicago*				
Element	*1968*	*1969*	*1966*	*1967*	*1968*	*1969*	*1966*	*1967*	*1968*	*1969*	*Composite Model**
Al		1.96									(2.0)
As		0.005									(0.005)
Cd	0.014		0.00	0.01		0.011	0.01	0.01	0.007	0.028	0.02
Cr		0.043	0.002	0.010		0.019	0.014	0.018	0.037	0.064	0.04
Cu	2.2	0.80	0.07	0.18		0.11	0.15	0.18	0.31	0.27	0.2
Fe		5.83	2.4	3.7	4.6	5.5	4.0	4.3	8.1	9.9	6.0
Mn		0.175	0.09	0.16	0.13	0.24	0.12	0.15	0.19	0.35	0.3
Ni		<0.019	0.014	0.026	0.020	0.029	0.036	0.035	0.056	0.104	0.06
Pb	1.8		0.8	1.2	0.93	1.2	1.0	1.2	1.1	2.6	1.5
Ti		0.185	0.00	0.02		0.05	0.02	0.02		0.10	(0.2)[a]
V		0.0084	0.017	0.034		0.048	0.042	0.050		0.115	0.08
Zn		0.44	0.5	0.7			1.5	1.0			(0.4)[a]

**Parentheses indicate considerable uncertainty in model concentrations due to limited number of measurements.*

[a]*Estimated from Harrison et al. (1971) only. National Air Surveillance Network data for these elements are not reliable (Winchester, 1975--personal communication; Akland, 1975--personal communication).*

References: Harrison and Winchester (1971); Harrison et al. (1971); National Air Surveillance Network--EPA, 1972, 1973a).

5.4 DATA ON MUNICIPAL AND INDUSTRIAL DISCHARGES AND SLUDGES

Tables 5.4-1 to 5.4-4 summarize the results of a study by the U.S. EPA Region V Eastern District Office to evaluate the levels of organic contaminants in effluents and sludges from wastewater treatment plants in Battle Creek, Jackson, Niles and Three Rivers (150). The predominant contaminants appear to be Aroclor 1242 and 1254, and phthalate esters.

Extensive surveys have been made of PCB levels in sludges and effluents in the Lake Michigan Basin. The PCB levels in Table 5.4-5 (151) in sludges from four wastewater treatment plants and from one industry ranged from 1.3 ppm to 15 ppm during 1973-74. A survey by the Wisconsin Department of Natural Resources (127) estimated that in 1975, 2000 lbs. of PCBs were discharged into Green Bay from major point sources along the lower Fox River. Most of this quantity came from mills which recycle waste papers. The daily estimated releases are shown in Table 5.4-6.

In 1978, Peterman et al. (152) reported the results of a study to assess the sources and distribution of organic compounds, particularly chloro-organics, in the 64 km Lower Fox River in northeastern Wisconsin. During 1976-77, about 250 samples were analyzed, including biota and 15 mill and 12 sewage treatment plant effluents. Table 5.4-7 lists the compounds identified in the study, and the concentration ranges for compounds which were quantified.

The presentation by Jones and Lee (87) summarized the results of many studies on the compounds found within municipal wastewater effluents and sludges. Table 5.4-8, which lists the results of a U.S. EPA sponsored study to identify organic compounds in the Muskegon wastewater system, is taken from the summary by Jones and Lee.

Tables 5.4-9 and 5.4-10 are obtained from the Wisconsin Department of Natural Resources publication "Surveys of Toxic Metals in Wisconsin". (125). Although many of the plants listed on Table 5.4-9 are not in the Great Lakes Basin, the information is included for purposes of comparison.

Table 5.4-11 shows the results of effluent analyses by U.S. EPA Region V.

Also of interest is the U.S. FDA study (158) which evaluated the effects of discharges of PCBs and PCB substitutes (Pydraul 50 E) from the Outboard Marine Co. outfall in Waukegon Harbor. The results are shown in Table 5.2-6. and 5.6-1.

TABLE 5.4-1

SAMPLE ANALYSIS RESULTS

BATTLE CREEK, MICHIGAN

WASTEWATER TREATMENT PLANT

NOVEMBER, 1973

PARAMETER	RAW WASTE (μg/L)	RAW WASTE (lbs/day)	EFFLUENT (μg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY	% REMOVAL
Arochlor 1221	<.001	<.0001	<.001	<.0001	<.001 <.001 <.001	
Arochlor 1232	<.001	<.0001	<.001	<.0001	<.001 <.001 <.001	
Arochlor 1242	140	15.1	110	11.8	<.001 2.250 <.001	21
Arochlor 1248	<.001	<.0001	<.001	<.0001	<.001 <.001 <.001	
Arochlor 1254	0.220	.023	.180	.02	2.200 5.090 1.3	18
Arochlor 1260	<.001	<.0001	<.001	<.0001	<.001 <.001 <.001	
Arochlor 1262	<.001	<.0001	<.001	<.0001	<.001 <.001 <.001	
Arochlor 1268	<.001	<.0001	<.001	<.0001	<.001 <.001 <.001	
Lindane	0.010	.001	.006	.0006	<.001 .013 <.001	40
Heptachlor	0.007	.0008	<.001	<.0001	<.001 <.001 <.001	>86
Aldrin	0.033	.004	0.005	.0005	<.001 <.001 <.001	85
Heptachlor epoxide	<.001	<.0001	0.027	.003	<.001 <.001 <.001	
Dieldrin	.49	.05	0.012	.001	.280 <.001 .0058	98
Endrin	<.001	<.0001	0.033	.004	.049 <.001 <.001	
o,p-DDT	<.001	<.0001	0.042	.005	.0075 .032 .048	
p,p-DDT	0.004	.0004	<.001	<.0001	<.019 .001 .016	75

TABLE 5.4-1 CONT'D
SAMPLE ANALYSIS RESULTS
BATTLE CREEK, MICHIGAN
WASTEWATER TREATMENT PLANT
NOVEMBER, 1973

PARAMETER	RAW WASTE (µg/L)	RAW WASTE (lbs/day)	EFFLUENT (µg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY	% REMOVAL
o,p-DDD	<.001	<.0001	<.001	<.0001	.031 .017 .0078	
p,p-DDD	<.001	<.0001	.026	.003	<.001 <.001 <.001	
o,p-DDE	.010	.001	<.001	<.0001	.100 .086 .120	>90
p,p-DDE	.007	.0008	<.001	<.0001	<.001 <.001 <.001	>86
Methoxychlor	.001	.0001	.001	.0001	<.001 .047 .031	
Di-N-Butyl phthalate	49	5.3	370	40	530 <50 143	
Di-2-ethyl phthalate	58	6.2	61	7	327 <50 85.7	
Chlordane	0.20	.021	<.001	<.0001	<.001 <.001 <.001	>99

TABLE 5.4-2
SAMPLE ANALYSIS RESULTS
JACKSON, MICHIGAN
WASTEWATER TREATMENT PLANT
OCTOBER, 1973

PARAMETER	RAW WASTE (μg/L)	RAW WASTE (lbs/day)	EFFLUENT (μg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY	% REMOVAL
Arochlor 1221	<.001	<.0001	<.001	<.0001	<.001	
Arochlor 1232	<.001	<.0001	<.001	<.0001	<.001	
Arochlor 1242	<.001	<.0001	<.001	<.0001	.47	
Arochlor 1248	<.001	<.0001	<.001	<.0001	<.001	
Arochlor 1254	1.5	.2	.4	.04	1.3	73
Arochlor 1260	<.001	<.0001	<.001	<.0001	<.001	
Arochlor 1262	<.001	<.0001	<.001	<.0001	<.001	
Arochlor 1268	<.001	<.0001	<.001	<.0001	<.001	
Lindane	.003	.0003	<.001	<.0001	.005	>67
Heptachlor	<.001	<.0001	.005	.0006	.006	
Aldrin	.022	.002	.018	.002	<.001	18
Heptachlor epoxide	<.001	<.0001	<.001	<.0001	<.001	
Dieldrin	.077	.009	.006	.0007	.024	92
Endrin	.068	.008	.004	.0004	.006	94
o,p-DDT	<.001	<.0001	<.001	<.0001	.011	
p,p-DDT	<.001	<.0001	.003	.0003	<.001	
o,p-DDD	<.001	<.0001	<.001	<.0001	.006	
p,p-DDD	<.001	<.0001	<.001	<.0001	.016	
o,p-DDE	<.001	<.0001	<.001	<.0001	<.001	
p,p-DDE	.006	.0007	.075	.008	<.001	
Methoxychlor	<.001	<.0001	<.001	<.0001	<.001	
Di-N-Butyl phthalate	190	20	8	.9	2	96
Di-2-ethyl phthalate	360	40	14	2	5	96
Chlordane	<.001	<.0001	<.001	<.0001	.18	

TABLE 5.4-3

SAMPLE ANALYSIS RESULTS

NILES, ILLINOIS

WASTEWATER TREATMENT PLANT

NOVEMBER, 1973

PARAMETER	RAW WASTE (µg/L)	RAW WASTE (lbs/day)	EFFLUENT (µg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY	% REMOVAL
Arochlor 1221	<.001	<.00002	<.001	<.00002	<.001	
					<.001	
					<.001	
Arochlor 1232	<.001	<.00002	<.001	<.00002	<.001	
					<.001	
					<.001	
Arochlor 1242	120	3	92	2	<.001	23
					<.001	
					<.001	
Arochlor 1248	<.001	<.00002	<.001	<.00002	<.001	
					<.001	
					<.001	
Arochlor 1254	.200	.005	.150	.004	8.0	25
					9.6	
					5.4	
Arochlor 1260	<.001	<.00002	<.001	<.00002	<.001	
					<.001	
					<.001	
Arochlor 1262	<.001	<.00002	<.001	<.00002	<.001	
					<.001	
					<.001	
Arochlor 1268	<.001	<.00002	<.001	<.00002	<.001	
					<.001	
					<.001	
Lindane	.005	.0001	.010	.0002	.0041	
					.089	
					.034	
Heptachlor	<.001	<.00002	<.001	<.00002	.010	
					.0097	
					.0052	
Aldrin	.004	.0001	.003	.00007	<.001	25
					<.001	
					<.001	
Heptachlor epoxide	.008	.0002	.014	.0003	.0056	
					<.001	
					.0025	
Dieldrin	.004	.0001	<.001	<.00002	2.400	>75
					1.800	
					1.300	
Endrin	.008	.0002	<.001	<.00002	.080	>88
					.056	
					.029	
o,p-DDT	.030	.0007	.003	.00007	.150	90
					.190	
					.090	
p,p-DDT	<.001	<.00002	<.001	<.00002	.0044	
					<.001	
					.0032	

TABLE 5.4-3 CONT'D

SAMPLE ANALYSIS RESULTS

NILES, ILLINOIS

WASTEWATER TREATMENT PLANT

NOVEMBER, 1973

PARAMETER	RAW WASTE (µg/L)	(lbs/day)	EFFLUENT (µg/L)	(lbs/day)	SLUDGE (mg/kg) DRY	% REMOVAL
o,p-DDD	.009	.0002	<.001	<.00002	.0072 <.001 <.001	>89
p,p-DDD	.008	.0002	.004	.0001	<.001 <.001 <.001	50
o,p-DDE	.007	.0002	<.001	<.00002	.540 .550 .320	>86
p,p-DDE	.002	.00005	.015	.0004	<.001 <.001 <.001	
Methoxychlor	.004	.0001	.004	.0001	.045 <.001 <.001	
Di-N-Butyl phthalate	340	8	76	2	192 301 67	78
Di-2-ethyl phthalate	88	2	51	1	320 415 143	42
Chlordane	<.001	<.00002	<.001	<.00002	<.001 <.001 <.001	

TABLE 5.4-4
SAMPLE ANALYSIS RESULTS
THREE RIVERS, MICHIGAN
WASTEWATER TREATMENT PLANT
NOVEMBER, 1973

PARAMETER	RAW WASTE (μg/L)	RAW WASTE (lbs/day)	EFFLUENT (μg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY	% REMOVAL
Arochlor 1221	<.001	<.000009	<.001	<.000009	<.001 <.001 <.001	
Arochlor 1232	<.001	<.000009	<.001	<.000009	<.001 <.001 <.001	
Arochlor 1242	100	.9	360	3	<.001 <.001 <.001	
Arochlor 1248	<.001	<.000009	<.001	<.000009	<.001 <.001 <.001	
Arochlor 1254	.17	.002	.58	.005	14.6 4.34 15	
Arochlor 1260	<.001	<.000009	<.001	<.000009	<.001 <.001 <.001	
Arochlor 1262	<.001	<.000009	<.001	<.000009	<.001 <.001 <.001	
Arochlor 1268	<.001	<.000009	<.001	<.000009	<.001 <.001 <.001	
Lindane	.005	<.00005	.004	<.00004	<.001 .0026 .054	20
Heptachlor	.007	.00006	.001	.000009	.019 <.001 .002	86
Aldrin	.016	.0001	.014	.0001	<.001 <.001 .0049	13
Heptachlor epoxide	<.001	<.000009	.012	.0001	.001 <.001 .019	
Dieldrin	.42	.004	<.001	<.000009	.44 .18 <.001	<99
Endrin	.067	.0006	.005	.00005	.006 .0078 <.001	93
o,p-DDT	<.001	<.000009	.001	.000009	<.001 .056 .12	
p,p-DDT	<.001	<.000009	<.001	<.000009	<.001 <.001 <.001	

TABLE 5.4-4 CONT'D
SAMPLE ANALYSIS RESULTS
THREE RIVERS, MICHIGAN
WASTEWATER TREATMENT PLANT
NOVEMBER, 1973

PARAMETER	RAW WASTE (µg/L)	RAW WASTE (lbs/day)	EFFLUENT (µg/L)	EFFLUENT (lbs/day)	SLUDGE (mg/kg) DRY	% REMOVAL
o,p-DDD	<.001	<.000009	<.001	<.000009	<.001 .0041 .0092	
p,p-DDD	.003	.00003	.001	.000009	<.001 <.001 <.001	67
o,p-DDE	.003	.00003	<.001	<.000009	.62 .085 .45	>67
p,p-DDE	<.003	<.00003	.001	.000009	<.001 <.001 <.001	67
Methoxychlor	.001	.000009	.001	.000009	<.001 <.001 <.001	
Di-N-Butyl phthalate	67	.6	44	.4	300 <50 <50	34
Di-2-ethyl phthalate	180	2	28	.3	585 <50 331	84
Chlordane	.097	.0009	.001	.000009	<.001 <.001 <.008	99

TABLE 5.4-5

RESULTS OF MODO PCB SURVEYS IN LAKE MICHIGAN BASIN
SOURCE: U.S. EPA, EDO, REGION V

FACILITY	LOCATION	RECEIVING WATERS	DATE	OUTFALL	PCBs - µg/L or µg/kg, dry** 1242	1248	1254
Battle Creek WWTP	Battle Creek	Kalamazoo	Nov/73	Inf.	140	*	.220
			"	Eff.	110	*	.180
			"	Sludge	*	*	2,220
			"	Sludge	2,250	*	5,090
			"	Sludge	*	*	1,300
Jackson WWTP	Jackson	Grand River	Oct/73	Inf.	*	*	1.5
			"	Eff.	*	*	0.4
			"	Sludge	470	*	1,300
Niles WWTP	Niles	St. Joseph	Nov/73	Inf.	120	*	.200
			"	Eff.	92	*	.150
			"	Sludge	*	*	8,000
				Sludge	*	*	9,600
				Sludge	*	*	5,400
Three Rivers WWTP	Three Rivers	St. Joseph	Nov/73	Inf.	100	*	.17
			"	Eff.	360	*	.58
			"	Sludge	*	*	14,600
			"	Sludge	*	*	4,340
			"	Sludge	*	*	15,000
Fedders Corp.	Greenville	Flat River	May/74	001(eff.)	0.23	*	*
			"	002	0.19	*	*
			"	003	0.23	*	*
Mead Corp.	Ostego	Kalamazoo	May/74	Int.	0.10	*	*
			"	001(eff.)	0.31	*	*
			"	005	0.27	4.5	*
			"	006	0.14	*	*
Hoover Ball & Bearing	Fowlerville	Red Cedar	June/74	Sludge #1	*	*	15,000
				Sludge #2	*	*	4,500
Michigan Tube	Eau Claire	Farmers Creek	Sept/74	001(eff.)	*	*	*
Dowaglac WWTP	Dowagiac	Dowagiac Creek	Oct/74	001(eff.)	*	*	*

*indicates not detectable.

**µg/L applies to influents (inf.) and effluents (eff.)
µg/kg applies to sludges.

TABLE 5.4-6

ESTIMATES OF PCB DISCHARGES TO GREEN BAY AND LAKE MICHIGAN FROM INDUSTRIAL AND MUNICIPAL EFFLUENTS

(Ref. 127)

River Basin	Wastewater Source	*Average Daily Discharge in gallons of Process Water	PCB Testing Date	Value in ppb	Ave. ppb	Estimated lbs./day of PCBs Discharged
Fox River	John Strange Paper (outfall #2)	480,000	Oct. 17, 1975	4		
			Jan. 27, 1976	2.6		
			April 1, 1976	.5	2.36	.009
Fox River	Bergstrom Paper Co.	3,876,000	Feb. 6, 1975	50		
			April 22, 1975	18		
			July 18, 1975	27		
			Sept. 26, 1975	62		
			Oct. 7, 1975	9.9		
			Nov. 26, 1975	75		
			Dec. 22, 1975	52		
			Jan. 9, 1976	75		
			Jan. 22, 1976	17		
			Jan. 30, 1976	19		
			Feb. 6, 1976	34		
			Feb. 13, 1976	36		
			March 11, 1976	10		
			July 20, 1976	5.5	35.2	1.132
Fox River	Kimberly-Clark (Lakeview Div)	3,430,000	Oct. 16, 1975	.28	.28	.008
Fox River	Neenah-Menasha WWTP	15,730,000	Oct. 16, 1975	.16		
			Jan. 20, 1976	.25	.21	.027
Fox River	Neenah Foundry (Plant #1)	830,000	Aug. 1, 1975	.10	.10	.0007
Fox River	Nennah Foundry (Plants #2 & 3)	1,317,000	Aug. 1, 1975	2.40	2.40	.026
Fox River	Riverside Paper	44,000	Feb. 12, 1976	3.60	3.60	.001
Fox River	Appleton WWTP	13,380,000	Feb. 13, 1973	.26		
			Feb. 16, 1973	.14		
			Aug. 24, 1973	.07	.16	.018
Fox River	Kimberly-Clark Corporation		Aug. 28, 1973	>.05	-	-
Fox River	Kimberly WWTP	590,000	Feb. 23, 1973	.15		
			Sept. 18, 1973	.35	.25	.001

TABLE 5.4-6 CONT'D

River Basin	Wastewater Source	*Average Daily Discharge in gallons of Process Water	PCB Testing Date	PCB Testing Value in ppb	Ave. ppb	Estimated lbs./day of PCBs Discharged
Fox River	Kaukauna WWTP	2,470,000	Feb. 15, 1973	.11		
			Oct. 3, 1973	.09		
			Oct. 15, 1974	.10	.10	.002
Fox River	Wrightstown WWTP	190,000	March 20, 1973	>.05	>.05	>.00007
Fox River	DePere WWTP	2,360,000	Feb. 15, 1973	.30		
			Oct. 15, 1974	.50	.40	.007
Fox River	Fort Howard Paper Co.	18,000,000	March 4, 1975	6.8		
			May 6, 1975	10		
			July 8, 1975	4.4		
			Aug. 21, 1975	14		
			Oct. 2, 1975	160		
			Dec. 19, 1975	56		
			Jan. 8, 1976	31		
			Jan. 15, 1976	31		
			Jan. 21, 1976	3.5		
			Jan. 28, 1976	6		
			Feb. 4, 1976	1.4		
			Feb. 12, 1976	3.2		
			April 21, 1976	1.2	25.27	3.793
Fox River	American Can	4,750,000	Jan. 25, 1976	.20		.008
Fox River	Charmin Paper	11,000,000	Jan. 14, 1976	.20		.018
Fox River	Green Bay Packaging	1,000,000	Oct. 21, 1974	.45		.004
Fox River	Green Bay WWTP	35,640,000	Jan. 22, 1976	.40		.119
Peshtigo R.	Badger Paper Mills	1,486,000	Oct. 30, 1974	.10		
			Aug. 21, 1975	.20	.15	.002
Peshtigo R.	Peshtigo WWTP	4,340,000	Aug. 21, 1975	.20		.007
Menominee R.	Scott Paper Co.	4,900,000	Oct. 30, 1974	.10		
			March 3, 1976	.60	.35	.014
Menominee R.	Marinette WWTP	2,620,000	Oct. 30, 1974	.10		.002
Oconto R.	Scott Paper Co.	8,360,000	Oct. 30, 1974	.10		.007
Fox River	Portage WWTP	890,000	July 31, 1974	7.4		
		890,000	April 16, 1975	4.2		
		1,014,000	May 28, 1975	6.8	6.13	.046

TABLE 5.4-6 CONT'D

River Basin	Wastewater Source	*Average Daily Discharge in gallons of Process Water	PCB Testing Date	PCB Testing Value in ppb	Ave. ppb	Estimated lbs./day of PCBs Discharged
Fox River	Fond du Lac WWTP	6,500,000 7,100,000	Feb. 27, 1973 May 23, 1975	.59 .2	.39	.218
Fox River	Oshkosh WWTP	8,400,000	Sept. 25, 1974	.1		.007
Fox River	Omro WWTP	87,000 108,000	March 2, 1973 Sept. 18, 1973	.25 1.2	.72	.0006
Twin River	Two Rivers WWTP	2,650,000 3,450,000	Sept. 23, 1975 March 4, 1976	.20 .70	.45	.012
Sheboygan R.	Vollrath #1 Vollrath #2	to STP to STP	June 10, 1975 June 10, 1975	.2 .2		
Sheboygan R.	Pt. Washington WWTP	1,590,000	Dec. 18, 1974	.20		.0026
Sheboygan R.	Sheboygan WWTP	11,300,000 11,600,000 9,400,000	Oct. 2, 1974 June 17, 1975 Dec. 15, 1975	1.1 .65 .2	.60	.060
Milwaukee R.	Jones Island WWTP	140,000,000	Oct. 15, 1974 Dec. 18, 1974	.5 .09	.30	.350
Milwaukee R.	S. Milwaukee WWTP	2,750,000	Sept. 17, 1974	.17		.004
Milwaukee R.	S. Shore Milwaukee WWTP	50,000,000	Sept. 18, 1974	.29		.12
Milwaukee R.	Appleton Elec-Lite	1,000	Jan. 5, 1976	3		.00002
Milwaukee R.	Babcock & Wilcox	900,000	July 24, 1975	.9		.007
Milwaukee R.	Briggs & Stratton #3	1,260,000 255,000	July 29, 1975 July 29, 1975	1.5 .2		.015 .0004
Milwaukee R.	Crucible Steel #1 #2 #3		July 28, 1975 July 28, 1975 July 28, 1975	<.1 <.1 <.1		- - -
Milwaukee R.	EST Grafton #1 #1 #2	4,300 4,300 14,200	April 4, 1975 July 28, 1975 July 28, 1975	.15 .1 .2		.000005 .000003 .00002
Milwaukee R.	Wehr Steel #1 #6	31,000	July 30, 1975 July 30, 1975	<.1 .2		- .00003

TABLE 5.4-6 CONT'D

River Basin	Wastewater Source	*Average Daily Discharge in gallons of Process Water	PCB Testing Date	Value in ppb	Ave. ppb	Estimated lbs./day of PCBs Discharged
Milwaukee R.	Meta Mold-Cedarburg - Cedarburg	21,000	July 28, 1975	5.6		.0009
	Milwaukee Die Casting	11,000	July 28, 1975	11.5		.001
	Milwaukee Solvay Coke #1	2,100,000	July 30, 1975	.1		.001
	Maynard Electric Steel #1		July 30, 1975	<.1		-
	Grey Foundry - W. Allis #2	19,000	July 31, 1975	.2		.00003
Root River	Caledonia WWTP	103,000	Feb. 28, 1973	.16		.0001
	Racine WWTP	16,900,000 16,920,000	Sept. 10, 1973 Dec. 18, 1974	.27 .1		.038 .014

*Average daily discharge figures are taken from Chapter NR 101 files (for industrial discharges) and from municipal waste water files for municipal discharged.

TABLE 5.4-7

COMPOUNDS IDENTIFIED IN GC/MS STUDY OF EFFLUENTS DISCHARGED INTO THE LOWER FOX RIVER, WISCONSIN

(Ref. 152)

Acetovanillone

Benzothiazole (10-30 ppb)

Chlorodehydroabietic acid

Chloroindole

Chloro-oxo-dehydroabietic acid

Chlorosyringaldehyde

Chlorotoluene

Chloroveratrole

Chloroxylenes

Dehydroabietic acid (100-3200 ppb)

Dichlorodiene resin acids

Dichloroguaiacol

Dichlorophenol (15-40 ppb)

Diphenylacetaldehyde
- mono, di, trichloro derivatives

Hydroxybenzothiazole (10-30 ppb)

Methylthiobenzothiazole (10-40 ppb)

Monochlorodiene resin acid

Monochlorophenol

PAHs (0.5-10 ppb)

PCBs (0.2-68 ppb)

Pentachloroanisole (0.05-0.78 ppb)

Pentachlorophenol (5-40 ppb)

Syringaldehyde

Tetrachlorodiene resin acids

Tetrachloroguaiacol (10-50 ppb)

Tetrachlorophenol (2-20 ppb)

Trans-stilbene oxide
- mono, di, trichloro derivatives

Trichloroaniline

Trichlorodiene resin acid

Trichlorodimethoxy phenol

Trichloroguaiacol (10-60 ppb)

Trichlorophenol (5-100 ppb)

TABLE 5.4-8

ORGANIC COMPOUNDS IDENTIFIED IN
MUSKEGON SYSTEM WASTEWATER

	Wastewater Sampled			
Pollutant	Influent	Aerated Lagoon Effluent	Holding Lagoon Effluent	Final Effluent
Dichloromethane[#]	+	+	+	+
1.2 Dichloroethane[#]	+	+	+	−
1.2 Dichloroethylene[#]	+	+	−	−
Toluene	+	+	−	−
Xylene[##]	+	+	+	−
Acetone	+	+	+	+
Dimethyl Sulfide	+	+	+	−
3-Pentanone	+	+	−	−
Dimethyl Disulfide	+	+	−	−
Dichlorobenzidine[#]	+	+	−	−
Phenol[#,##]	+	−	−	−
Ethylbenzene[#]	+	−	−	−
Trichlorobenzene[#]	+	−	−	−
Diazobenzene	+	+	+	−
Dichlorobenzophenone	+	+	+	−
Aniline[##]	+	+	?	−
N-Ethylaniline	+	−	−	−
N,S-Diethylaniline	+	−	−	−
N,N-Dimethylaniline[##]	+	+	+	−
Chloroaniline[##]	+	+	+	−
Benzothiazole	+	−	−	−
Benzyl Alcohol[##]	+	+	−	−
Cresol[##]	+	−	−	−
Methoxy Phenol[##]	+	−	−	−
Hydroxymethoxyacetophenone	+	+	+	−
Dimethoxyacetophenene	+	+	−	−
Chloropropiophenone	+	−	−	−
Hexanoic Acid[##]	+	+	?	−
Decanoic Acid[##]	+	+	?	−
Dodecanoic Acid	+	+	−	−
Tetradecanoic Acid	+	?	+	−
Hexadecanoic Acid	+	+	+	+
Heptadecanoic Acid	+	+	+	−
Octadecanoic Acid	+	+	+	−
α -Pinene	+	−	−	−
β -Pinene	+	−	−	−
α -Terpineol	+	−	−	−
Trithiapentane[##]	+	+	−	−
Tetrathiohexane[##]	+	+	+	−
2-Ethyl-1-hexanol	+	−	−	−
Isoborneol	+	+	−	−

TABLE 5.4-8 (CONT'D)

ORGANIC COMPOUNDS IDENTIFIED IN
MUSKEGON SYSTEM WASTEWATER

Pollutant	Influent	Aerated Lagoon Effluent	Holding Lagoon Effluent	Final Effluent
	Wastewater Sampled			
Decanol	+	−	−	−
Dodecanol	+	+	−	+
Tetradecanol	+	−	−	+
2-(2-(2-ethoxyethoxy) ethoxy) ethanol	+	−	−	−
Tetradecene	−	+	−	−
Trimethylisocyanurate	−	−	+	+
Atrazine	−	−	−	+
Heptanoic Acid†	−	††	+	−
Octanoic Acid†	+	††	+	−
Nonanoic Acid†	+	††	+	−
Pentadecanoic Acid†	−	††	+	−
O-Phenyl Phenol†	+	††	−	−
Benzoic Acid†	+	††	+	−
Phenylacetic Acid†	+	††	−	−
Salicylic Acid†	+	††	−	−
Phenylpropionic Acid†	+	††	−	−
Vanillin†	+	††	−	−
Acetovanillin†	+	††	−	−
Homovanillin†	+	††	−	−
2-(4-Chlorophenoxy) 2-Methyl† Propionic Acid	+	††	+	−

*Presence or absence of pollutant in wastewater is indicated by + or −. "?" indicates presence suspected but not confirmed beyond reasonable doubt.

**Unless noted otherwise, listed compounds were identified in daily samples at RSKERL.

#Compounds appearing on the EPA "List of Dangerous Pollutants."

##Identified in both daily samples at RSKERL and composite samples at AERL.

†Identified in composite samples at AERL.

††Composite samples of aerated lagoon effluent were not obtained.

TABLE 5.4-9

(Ref. 125)

ANNUAL POUNDAGE OF METAL WASTES DISCHARGED TO THE AIR, WATER AND SOIL IN SELECTED AREAS

	Annual Poundage Discharged to the Air, Water, and Soil*					
Metal	Milwaukee Area	Racine Kenosha Area	Fox River Valley Marinette Peshtigo	Central Wisconsin Area	Grafton Mayville Horicon Beaver Dam Hartford Ripon Fond du Lac	Sheboygan Kohler Manitowoc Two Rivers
Arsenic	-	-	1,800	530	-	-
Beryllium	50	-	-	-	-	-
Cadmium	754	-	30	-	4,743	-
Chromium	19,460	31,777	3,360	1,591	3,516	8,430
Copper	6,688	74,099	3,820	2,150	870	405
Lead	2,500	117,965	-	380	-	861
Mercury	-	-	-	29	-	-
Nickel	22,933	3,214	50	3,038	615	-
Selenium	-	-	-	5,907	-	-
Zinc	64,443	97,115	55	58,007	8,875	10,145
Total	116,828	324,170	9,115	71,632	18,619	19,841

*all sites are not in the Lake Michigan Basin, and are included for comparison.

TABLE 5.4-10

Concentrations of Metals in the Influent, Effluent and Final Digested Sludge from Selected Wisconsin Sewage Treatment Plants. *

Plant	Chromium			Copper			Lead			Zinc			Cadmium			Mercury			Nickel		
	I*	E*	S*	I	E	S	I	E	S	I	E	S	I	E	S	I	E	S	I	E	S
Appleton	0.32	1.4	5,400	0.13	0.056	1,200	0.28	<0.08	3,300	0.88	<0.08	3,600	0.008	0.016	13	<0.0005	<0.0005	11.5	0.04	0.08	15
Beaver Dam	0.1	0.02	690	0.04	0.02	370	0.1	<0.05	440	0.2	<0.04	1,500	<0.02	<0.02	15	<0.0005	<0.0005	2.7	0.28	0.2	950
Beloit	0.04	<0.02	260	0.11	<0.02	700	0.08	<0.08	350	0.35	0.65	2,400	<0.01	<0.01	20	0.0016	0.0005	10	<0.08	<0.08	40
Chippewa Falls	0.04	0.05	500	0.9	0.06	1,500	0.5	<0.08	530	1.0	0.1	1,750	0.015	<0.01	10	0.0028	<0.0005	5	<0.08	<0.08	25
DePere	0.12	0.08	1,250	0.012	0.028	490	0.08	0.08	700	0.8	0.34	4,100	0.008	<0.008	37	0.0008	0.0003	5.9	<0.04	<0.04	20
Eau Claire	0.2	0.2	6,400	1.4	0.8	10,000	0.2	<0.2	730	1.0	0.8	6,000	<0.02	<0.02	15	0.0009	0.0008	7	<0.04	<0.04	85
Fond du Lac	14.0	1.8	32,000	0.13	0.04	350	0.3	0.1	990	0.42	0.08	1,550	0.09	0.03	40	0.0013	<0.0005	5.8	0.12	0.12	90
Green Bay MSD	0.20	0.12	290	0.06	0.044	440	0.20	0.16	300	0.38	0.18	1,920	0.016	<0.008	13	<0.0007	<0.0005	2.4	0.14	0.12	140
Janesville	0.20	0.4	2,000	0.1	0.1	1,400	<0.08	0.08	220	0.15	0.2	2,300	<0.02	<0.02	65	<0.0005	<0.0005	2.2	0.15	0.2	520
Kaukauna	0.08	0.03	640	0.056	0.02	1,300	0.2	<0.08	2,200	0.18	0.09	1,400	0.02	0.008	10	0.08	<0.0005	3.6	0.08	<0.04	20
Kenosha	0.28	<0.05	2,000	0.04	<0.05	2,900	0.4	<0.08	550	1.40	0.48	5,500	0.02	<0.02	110	0.001	<0.0005	0.6	0.08	0.1	220
La Crosse	0.4	0.4	1,270	0.17	0.15	1,050	0.3	0.2	530	1.40	0.8	2,280	0.03	0.03	30	0.0008	0.0005	5.4	<0.04	<0.04	50
Madison MSD	0.08	0.06	350	0.08	0.025	670	0.08	0.08	410	0.37	0.12	4,200	0.008	0.008	22	0.013	<0.0005	17.5	0.04	0.04	55
Manitowoc	0.6	0.3	2,300	0.2	0.1	1,300	0.1	0.08	740	1.0	0.5	5,300	0.03	<0.02	100	0.0006	<0.0005	7.1	0.3	0.2	900
Marshfield	0.32	<0.05	800	0.3	0.06	1,500	<0.08	<0.08	300	0.26	0.04	1,800	<0.02	<0.02	13	0.0025	0.0015	22	0.24	<0.05	200
Menomonie	<0.04	0.04	90	0.04	0.04	390	<0.08	<0.08	450	0.22	0.38	1,800	<0.008	0.008	14	0.008	0.008	13.3	<0.04	<0.04	50
Milwaukee MSD																					
1. Jones Is.	2.1	0.1	7.400	0.07	<0.05	500	0.16	<0.08	850	1.0	0.16	3,400	0.06	<0.02	185	0.006	0.0008	—	0.12	<0.05	140
2. S. Shore	5.6	1.5	16,000	0.48	0.36	270	0.3	<0.08	1,350	0.68	0.2	2,900	<0.02	<0.02	15	0.001	0.0008	2.6	0.2	0.1	340
Neenah-Menasha	0.16	0.05	70	0.11	0.15	140	0.2	0.1	200	0.32	0.2	490	<0.01	<0.01	12	0.0015	0.001	7.3	<0.05	<0.05	25
N. Fond du Lac	3.6	2.9	8,500	0.11	0.10	1.780	0.006	0.004	680	0.56	0.48	4.200	<0.002	<0.002	30	0.005	0.004	18	3.0	2.6	7,500
Oshkosh	0.2	0.06	310	0.04	0.02	176	0.1	<0.1	190	0.2	0.08	1.200	0.01	0.01	7	<0.0005	<0.0005	2.4	<0.04	<0.04	15
Portage	<0.05	<0.05	120	<0.05	<0.05	350	<0.1	0.1	500	0.1	0.1	1,800	<0.01	<0.01	12	0.0015	0.001	7.3	<0.05	<0.05	25
Racine	0.24	0.16	3.500	0.14	0.08	2,850	0.2	0.2	4,600	0.44	0.38	8,000	<0.02	<0.02	170	0.24	0.001	8	<0.05	0.07	250
Rhinelander	0.25	0.07	500	0.1	0.1	950	0.2	0.1	1,100	0.35	0.3	2,450	<0.01	0.01	18	0.0006	0.0006	4.4	<0.08	<0.08	220
Ripon	0.6	0.2	1,800	0.12	0.06	470	0.16	0.08	490	0.64	0.38	2,800	0.08	0.04	270	0.0007	0.0006	1.8	0.5	0.32	1.600
Sheboygan	7.4	3.2	13,600	0.08	0.2	165	0.08	0.08	230	1.2	1.0	3,400	0.02	<0.02	20	0.0011	0.0006	2.4	0.08	0.06	75
S. Milwaukee	3.6	2.6	22,500	0.05	<0.05	280	<0.08	<0.08	270	0.14	0.12	620	<0.02	<0.02	<10	<0.0005	<0.0005	1.5	<0.05	<0.05	20
Stevens Point	<0.05	<0.05	50	<0.02	<0.05	290	<0.08	<0.08	100	0.34	0.08	650	<0.02	<0.02	210	0.003	0.002	3.9	<0.05	<0.05	<10
Superior	<0.05	<0.05	220	0.25	0.1	850	<0.08	<0.08	860	0.24	0.28	1.350	<0.02	<0.02	10	0.001	0.001	31	<0.05	<0.05	30
Two Rivers	0.2	0.1	450	0.1	0.07	520	0.15	0.2	850	0.5	0.5	4.300	<0.02	0.02	170	0.0007	<0.0005	2.7	0.28	0.2	950
Watertown	0.35	0.1	1.100	0.4	0.06	1.030	0.08	<0.08	400	1.2	0.25	1,130	0.01	0.01	13	<0.0005	<0.0005	4	0.15	0.15	250
Waukesha	<0.05	<0.05	2.070	0.07	<0.05	2.680	<0.08	<0.08	980	0.24	0.16	12.200	<0.02	<0.02	18	0.0008	<0.0005	11	<0.05	<0.05	170
West Bend	0.17	<0.05	800	0.07	0.06	580	0.68	0.08	1.400	0.28	0.12	3.500	0.02	<0.02	400	0.004	0.001	8.5	<0.05	<0.05	135
Whitewater	0.15	<0.05	215	0.15	<0.05	420	<0.08	<0.08	245	0.4	0.08	1.370	<0.02	<0.02	<10	<0.0005	0.001	—	<0.05	<0.05	20
Wisconsin Rapids	0.6	0.22	2,650	<0.05	<0.05	300	<0.08	<0.08	400	0.12	0.04	1.220	<0.02	<0.02	150	0.002	<0.0005	5	0.64	0.5	1.700

*I = Influent (concentration expressed as mg/l)
E = Effluent (concentration expressed as mg/l)
S = Sludge (concentration expressed as mg/kg dry weight)

*all sites are not in the Lake Michigan Basin, and are included for comparison.

TABLE 5.4-11

EPA REGION V - ANALYSES OF WASTEWATER

DISCHARGES TO LAKE MICHIGAN 1975-76

Point Source Discharges	Parameter
	Mercury Levels >.5μg/L
Appleton WWTP, WI	50 μg/l
Scott Paper Co., Onconto Falls, WI	22 μg/L
Fansteel Inc., N. Chicago, IL	0.9 μg/L
	Arsenic Levels >250 μg/L
Ansul Company, Marinettee, WI	1540 μg/L
Marinette WWTP, WI	675 μg/L
	Lead Levels >100 μg/L
Appleton WWTP	3,000 μg/L
Briggs & Stratton Corp., West Allis, WI	1,020 μg/L
Republic Steel, Calumet River, IL	350 μg/l

5.5 DATA ON BENTHOS AND PLANKTON

Table 5.5-1, taken from the report of the Environmental Research Group (132), shows the average trace element concentrations found in Lake Michigan phytoplankton, zooplankton, benthos and fish. Concentration factors (relative to water concentrations) were calculated, and are shown in Table 5.5-2.

Veith (161) in 1973 reported PCB concentrations of 0.06 mg/kg in the amphipod *Pontoporeia* collected near Sturgeon Bay, compared to 0.45 mg/kg in *Pontoporeia* collected offshore from Waukegon.

TABLE 5.5-1

AVERAGE TRACE ELEMENT CONCENTRATIONS FOUND IN LAKE MICHIGAN BIOTA (132)

Parts Per Million (wet weight)

	PHYTOPLANKTON	ZOOPLANKTON	BENTHOS	FISH[3]
Ag	.09	.04	.10	.01
Al	419	99	83	N.D.
As	1.5	1	2	N.D.
Au	.004	.002	.003	.0001
Ba	6	4	6	N.D.
Br	8	88	36	N.D.
Ca	2000[1]	1750[1]	2320	N.D.
Ce	<.5	.2	.39	N.D.
Cl	118	1440	1972	N.D.
Co	.083	.05	.06	.005
Cr	.43	.35	.65	.01
Cs	.002	.007	.033	.02
Cu	6	5	7	N.D.
Eu	.002	.002	.0017	N.D.
Fe	55	40	35	[3]
Hf	.009	.005	.006	N.D.
Hg	.16	.09	.14	.15
I	.80	.91	.50	<.5
K	725[1]	970[1]	870[1]	N.D.
La	.22	.066	.073	N.D.
Lu	<.02	.01	.01	N.D.
Mg	316[1]	240[1]	500[1]	N.D.
Mn	11	3.7	13.7	.2
Mo	.7	5.9	3.9	N.D.
Na	310[1]	265[1]	540[1]	N.D.
Rb	1.1	1.8	2.2	[3]
Sb	.07	.08	.017	.001
Sc	N.D.[2]	.01	.011	.0003
Se	.19	.60	.48	.5
Sm	<.1	.015	.08	N.D.

TABLE 5.5-1 CONT'D

	PHYTOPLANKTON	ZOOPLANKTON	BENTHOS	FISH[3]
Sr	14	11	7.5	<3
Th	<.02	.007	.007	N.D.
V	.38	.08	.065	N.D.
Yb	<.2	<.2	<.2	N.D.
Zn	27	23	14	9

[1] Data by Atomic Absorption.

[2] N.D. - Not Determined.

[3] Edible Portions, not containing skeletal material or the internal organs.

TABLE 5.5-2

(Ref. 132)

CONCENTRATION FACTORS IN LAKE MICHIGAN BIOTA[1]

ELEMENT	PHYTOPLANKTON	ZOOPLANKTON	BENTHOS
Ag	300	133	330
Al	15500	3660	3074
As	1500	1000	2000
Au	2000	1000	1500
Ba	162	108	162
Br	160	1760	720
Ca	57	50	66
Ce	N.D.[2]	285	557
Cl	10	130	179
Co	461	277	333
Cr	252	206	382
Cs	143	500	2357
Cu	≈1200	≈1000	≈1400
Eu	232	232	197
Fe	2890	2105	1840
Hf	2250	1250	1500
Hg	5900	3330	5185
I	800	910	500
K	453	606	543
La	1100	330	365
Lu	N.D.	N.D.	N.D
Mg	27	21	43
Mn	N.D.	3700	3700
Mo	350	1950	1950
Na	62	53	108
Rb	1100	2200	2200
Sb	304	347	74
Sc	N.D.	3330	3660
Se	2290	7230	5783
Sm	N.D.	500	2666
Sr	144	113	77
Th	N.D.	2920	2916
V	1900	400	325
Yb	N.D.	N.D.	N.D.
Zn	1690	1440	875

1.) These concentration factors were calculated from the equation:

$$\text{Concentration Factor} = \frac{\text{Concentration in Organism}}{\text{Concentration in Water}}$$

2.) N.D. = Not Determined

5.6 DATA ON FISH CONTAMINANTS

In the Lake Michigan Basin, there are several ongoing programs within which fish are analyzed for various contaminants. For example, the U.S. Fish and Wildlife National Pesticide Monitoring Program analyzes whole fish samples from nearshore areas, for various organic pesticides. The Great Lakes Environmental Contaminants Survey (GLECS), obtains samples from eight zones within Lake Michigan. These zones are shown in Figure 5.6-2. The Wisconsin Department of Natural Resources samples fish from approximately nine tributaries to Lake Michigan and from Lake Michigan itself (i.e. Green Bay), for determination of heavy metal and organic contaminant concentrations. Most of the data in this section which emphasizes recent and trend analyses was obtained from the above noted programs (Table 5.6-1). Additional information on pesticide and PCB levels in Lake Michigan fish can be found in reference 131, "Chemistry of Lake Michigan."

Organic Contaminants

The average concentrations of DDT, dieldrin and PCBs in bloaters, coho salmon and lake trout from 1969-76, are shown in Table 5.6-2 and Figure 5.6-1. DDT concentrations have decreased steadily, to approximately 10-25% of the 1969 concentrations. The lower levels of PCBs noted for 1976 may indicate the start of a downward trend, or they may be a random perturbation of the data. Dieldrin levels have not changed.

An example of the GLECS data for Lake Michigan fish contaminants (157) is shown in Table 5.6-3. Tables 5.6-4 and 5.6-5 outline the results of the Wisconsin Department of Natural Resources study on PCB levels on various species of fish (127). Very high concentrations of PCBs are noted for several species in various locations.

The concern for the presence of PCBs within the Lake Michigan ecosystem has resulted in several special studies. Stauffer (153) attempted to evaluate the concentrations of DDT and PCBs in fish eggs (Table 5.6-6). The Chicago Department of Health (154) and the Wisconsin Department of Natural Resources (127) evaluated the concentrations of PCBs in commercially available fish (Tables 5.6-7 and 5.6-8). The study by the Chicago Department of Health found no significant changes in the PCB concentrations after cooking the fish by various methods.

Several recent results have been reported on compounds other than PCBs, DDT, dieldrin, etc. Ludke (156) reported the presence of a chlorinated camphene contaminant which had been earlier reported as toxaphene in lake trout. Veith (108) found dichloro benzene, cis and trans-chlordane and trans-nonachlor in fish from Green Bay. The U.S. FDA (158) identified several phenyl phosphates in carp from Waukegan Harbor. Sills and Allen (106), however, could not detect any TFM in lake trout.

Heavy Metals

Tables 5.6-9 and 5.6-10 (125) illustrate some of the heavy metal concentrations observed in Lake Michigan fish. The averaged mercury levels were below .5 ppm. A special study (124) showed that most of the mercury detected in Wisconsin fish was in the form of methyl mercury.

TABLE 5.6-1

ORGANIC COMPOUNDS IDENTIFIED IN
LAKE MICHIGAN FISH TISSUE

DATE	LOCATION	COMPOUNDS IDENTIFIED	CONCENTRATIONS (ppm)	SPECIES	SOURCE
1969-76	Saugatuck	DDT, Dieldrin, PCBs	See Table 5.6-2	Bloater	155
1969-76	East Central Lake Michigan	DDT, Dieldrin, PCBs	See Table 5.6-2	Coho Salmon	155
1970-76	Saugatuck	DDT, Dieldrin, PCBs	See Table 5.6-2	Lake Trout	155
1974	Whole Lake	Chlorinated camphene	N.I. (a)	Lake Trout	156
1974	Whole Lake	DDT, PCB, Dieldrin	See Table 5.6-3		157
1974-76	Wisconsin waters	PCB	See Table 5.6-5 5.6-4		
1976	Green Bay	Dichlorobenzene	N.I. (a)	N.I.	108
		Cis-chlordane			
		Trans-chlordane			
		Trans-nonachlor			
1976	Waukegan Harbor	Triphenyl phosphate	0.06-0.12	Carp	158
		Diphenylnonylphenyl phosphate	0.16-0.28		
		Diphenylcumylphenyl phosphate	0.22-0.41		
		DDE	0.8-1.4		
		PCB	7-8		
COMPOUNDS SOUGHT BUT NOT DETECTED					
1973	Saugatuck	3-trifluoromethyl-4 nitrophenol (TFM)		Lake Trout	106
		Detection Level - 0.01 ppm			

(a) N.I. - not indicated

TABLE 5.6-2

Concentrations of pesticides and PCBs in fall collections of Lake Michigan bloaters and lake trout off Saugatuck, Michigan, and coho salmon from east-central Lake Michigan. (Ref. 155)

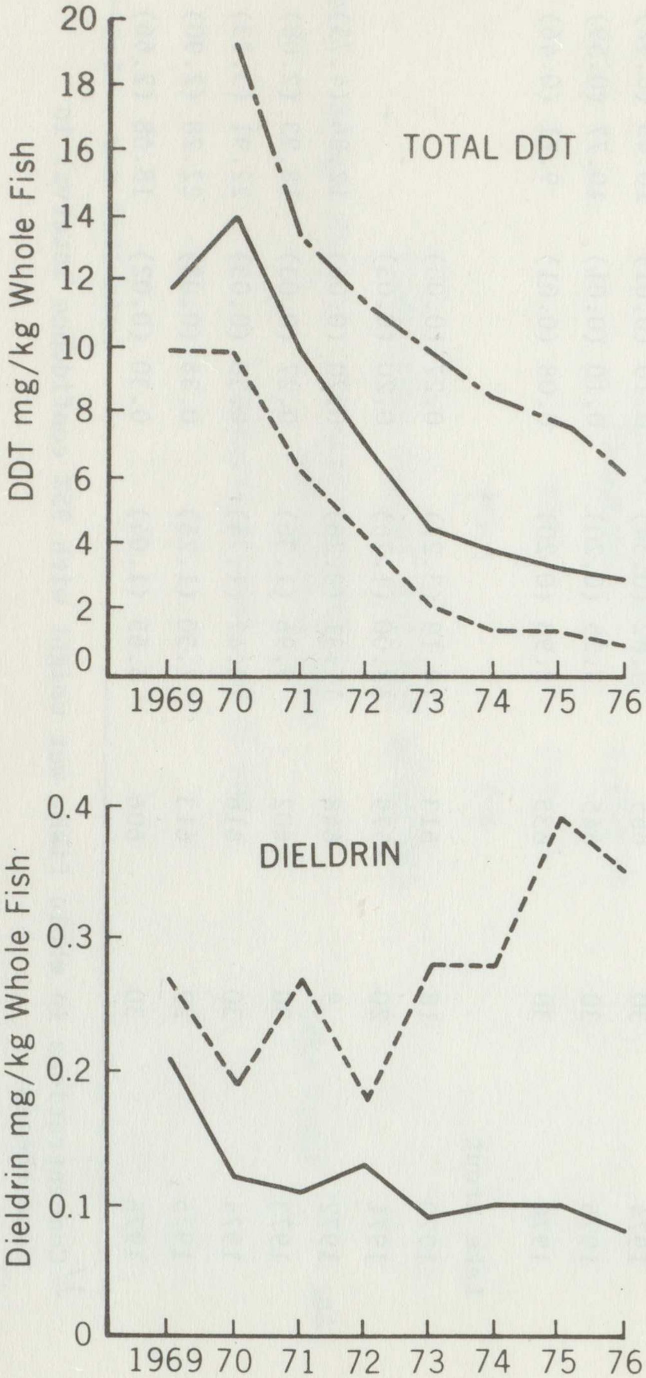
Species and Year	Number of fish	Average length (mm)	Total DDT µg/g [1/]	Dieldrin µg/g [1/]	Total PCBs µg/g [1/]
Bloaters					
1969	120	270	9.94 (0.33)	0.27 (0.01)	-
1970	28	263	9.87 (1.44)	0.19 (0.02)	-
1971	60 [2/]	264	6.24 (1.13)	0.27 (0.06)	-
1972	120 [3/]	255	4.33 (0.48)	0.18 (0.03)	5.66 (0.95)
1973	160 [3/]	250	2.09 (0.26)	0.28 (0.02)	5.24 (0.37)
1974	110 [3/]	257	1.33 (0.14)	0.28 (0.03)	5.57 (0.31)
1975	170 [3/]	249	1.27 (0.20)	0.39 (0.03)	4.54 (0.36)
1976	110 [3/]	253	0.90 (0.06) [4/]	0.35 (0.02)	4.11 (0.22)
Coho salmon					
1969	11	621	11.82 (2.69)	0.21 (0.02)	-
1970	13	651	14.03 (1.29)	0.12 (0.02)	-
1971	15	674	9.85 (1.41)	0.11 (0.01)	-
1972	10	693	7.17 (1.09)	0.13 (0.04)	10.93 (2.12)
1973	29	620	4.48 (0.34)	0.09 (0.01)	12.17 (0.77)
1974	30	665	3.82 (0.34)	0.10 (0.01)	10.45 (0.92)
1975	30	645	3.25 (0.20)	0.10 (0.01)	10.77 (0.59)
1976	30	635	2.98 (0.20)	0.08 (0.01)	9.21 (0.46)
Lake trout					
1970	18	613	19.19 (3.27)	0.27 (0.05)	-
1971	20	579	13.00 (1.76)	0.20 (0.03)	-
1972	9	648	11.31 (3.26)	0.20 (0.06)	12.86 (4.75)
1973	30	602	9.96 (1.36)	0.27 (0.03)	18.93 (2.08)
1974	30	616	8.42 (1.74)	0.30 (0.03)	22.91 (3.73)
1975	29	613	7.50 (1.25)	0.35 (0.03)	22.28 (2.90)
1976	30	606	5.65 (1.04)	0.30 (0.02)	18.68 (2.66)

[1/] Concentrations in whole fish, wet weight with 95% confidence interval in parentheses.

[2/] Composite samples, 5 fish/sample.

[3/] Composite samples, 10 fish/sample.

[4/] p,p-DDT plus p,p-DDE measured as DDE in saponified samples.



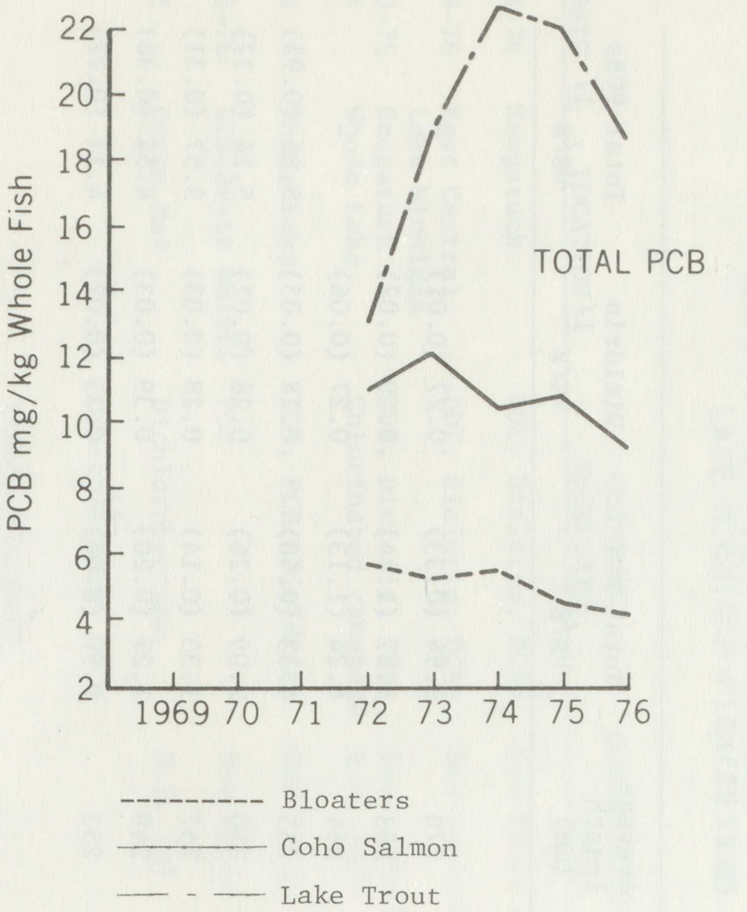


FIGURE 5.6-1
MEAN CONCENTRATIONS OF CHLORINATED HYDROCARBONS IN FISH FROM EASTERN LAKE MICHIGAN (U.S. FWS DATA)

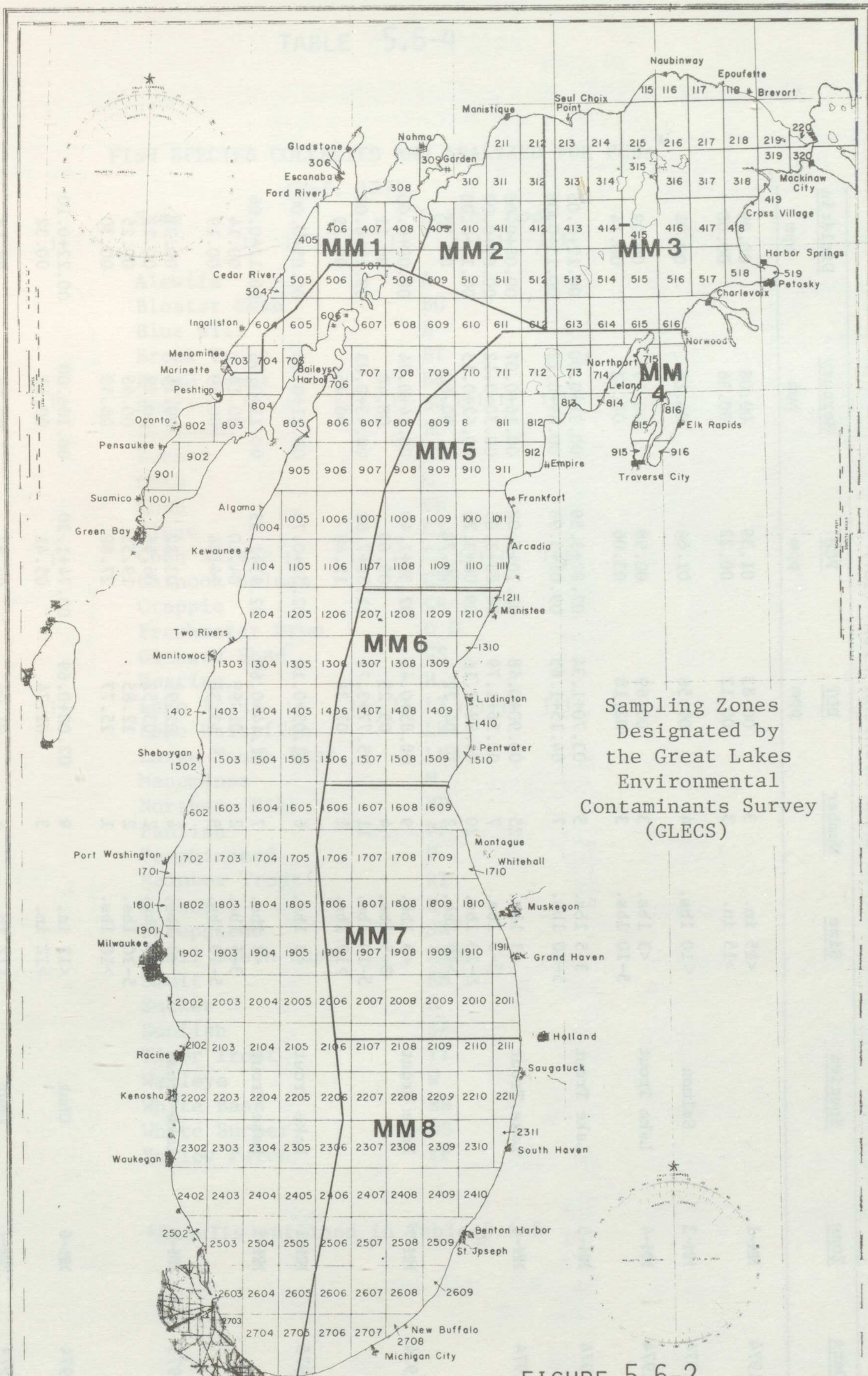


FIGURE 5.6-2
LAKE MICHIGAN

☆ U.S. GOVERNMENT PRINTING OFFICE: 1973-761-578

TABLE 5.6-3

SUMMARY OF GLECS DATA
CONTAMINANTS IN LAKE MICHIGAN FISH (157)

Date	Zone	Species	Size	Number	DDT ppm	PCB ppm	Mercury ppm	Dieldrin ppm
1974	MM-1		<15 in.	3	00.83	01.39	00.08	00.09
			>15 in.	3	00.12	00.22	00.36	00.00
1974	MM-3	Salmon	<10 lbs.	4	00.56	01.64	00.18	00.04
1974	MM-4	Lake Trout	<3 lbs.	3	00.69	00.99	00.15	00.09
			5-10 lbs.	3	02.18	03.06	00.32	00.14
1974	MM-5	Lake Trout	3-5 lbs.	5	03.70±1.34	07.92±3.59	00.32±0.00	00.12±0.05
			5-10 lbs.	7	04.15±1.65	09.01±3.98	00.49±0.12	00.15±0.06
1974	MM-6	Lake Trout	<3 lbs.	25	00.90±0.48	02.10±1.02	00.16±0.07	00.08±0.00
			3-5 lbs.	7	02.56±1.79	04.83±3.05	00.30±0.12	00.09±0.03
			5-10 lbs.	20	04.88±2.16	09.08±3.26	00.52±0.15	00.12±0.00
			>10 lbs.	2	04.72	09.70	00.60	00.18
1974	MM-7	Lake Trout	<3 lbs.	9	00.85±0.43	02.39±1.49	00.14±0.04	00.08±0.00
			3-5 lbs.	4	03.25	05.69	00.40	00.11
			5-10 lbs.	11	05.77±3.73	11.86±7.02	00.43±0.03	00.18±0.08
			>10 lbs.	2	07.34	15.48	00.46	00.19
1975	MM-1	Lake Trout	<3 lbs.	6	01.03±0.18	02.58±0.75	00.11±0.00	00.05±0.00
	MM-5	Lake Trout	<3 lbs.	7	01.44±0.60	02.93±1.35	00.11±0.03	00.12±0.06
			3-5 lbs.	2	01.99	04.10	00.16	00.14
			5-10 lbs.	3	13.34	24.84	00.49	00.19
1975	MM-6	Lake Trout	<3 lbs.	4	01.95	03.82	00.16	00.21
			3-5 lbs.	2	03.52	06.56	00.19	00.22
			5-10 lbs.	2	12.85	19.55	00.45	00.25
			>10 lbs.	1	25.77	27.80	00.53	00.30
1974	MM-6	Chub	<12 in.	9	02.08±0.69	03.74±1.20	00.10±.00	00.22±0.10
			>12 in.	3	02.74	05.41	00.11	00.32
1974	MM-7	Chub	<12 in.	4	01.04	02.87	00.13	00.12
			>12 in.	7	02.23±0.97	03.26±0.94	00.15±0.04	00.24±0.07
1974	MM-1	Burbot		6	00.12±0.07	00.30±0.24	00.18±0.04	00.00±0.00

TABLE 5.6-4

FISH SPECIES COLLECTED AND ANALYZED FOR PCBs*

(Ref. 127)

Name	Letter Code
Alewife	A
Bloater Chub	BC
Blue Gill	B
Brook Trout	BT
Brown Trout	BR
Bowfin	BW
Bullhead	BU
Burbot	BB
Carp	C
Chub	CH
Cisco	CI
Coho Salmon	CS
Chinook Salmon	CN
Crappie	CR
Freshwater Drum	D G
Gizzard Shad	GS
Herring	H
Lake Trout	LT
Lake Whitefish	LW
Large Mouth Bass	LMB
Menominee	M
Northern Pike	NP
Panfish	PF
Pumpkinseed	P
Rainbow Trout	RT
Redhorse	R
Sheepshead	SH
Small Mouth Bass	SMB
Smelt	SM
Sucker	S
Sunfish	SF
Tiger Trout	TT
Walleye	W
White Bass	WB
White Sucker	WS
Yellow Perch	YP

*Results outlined in Table 5.6-5

TABLE 5.6-5

PCB LEVELS IN FISH FROM VARIOUS WISCONSIN WATERS IN THE LAKE MICHIGAN BASIN

Fish Collection Description					ppm PCB		
SITE	DATE	SPECIES SAMPLED	PORTION ANALYZED**	% FAT	LOW	x̄	HIGH
Grid #0608 & 0609	05/77	1CH*	WF	23.5	3.3	3.3	3.3
Bailey's Harbor	11/74	3BR	EP	15.2	1.6	4.3	6.6
Bailey's Harbor	04/77	10LW	F	10.5	0.9	1.1	1.7
Sturgeon Bay	05/71	15LT	EP	–	1.1	11.9	41.3
Sturgeon Bay	11/74	1BR, 3LT	EP	9.3	3.5	10.1	25.5
Sturgeon Bay	06/75	3LT	F	10.0	2.7	11.7	26.5
Grid #0905	06/75	6PR	EP	2.1	1.6	3.3	5.0
Algoma	11/74	1CN	EP	0.9	15	15	15
		17CS	EP	3.5	0.2	5.5	10.5
		2BR	EP	11.6	1.6	3.5	5.3
		1TT	EP	4.5	4.9	4.9	4.9
		27LT	EP	15.1	2.1	17.2	43.8
Algoma Grid #1004	09/75	10LT, 10LT	WF,F	8.8	1.6	5.6	14.9
Kewaunee	06/76	8LT	F	17.4	1.9	13.4	21.0
		2WF, 22YP, 6S	F	24.5	0.6	1.2	2.3
Two Rivers Harbor	06/76	1LT, 1BT, 2BR, 1LW, 1WF, 4S	F				
		5A	WF	5.8	0.8	3.3	5.6
	05/77	4CH	EP	16.9	2.4	2.9	3.4
Manitowoc Harbor	06/76	1CS, 2LT, 3BR, 1BT, 1RT, 2LW	F	10.1	1.8	8.2	7.2
Sheboygan #1502	05/75	2BR	F	11.5	0.0	1.7	3.4
		8LT	F	9.9	0.1	5.9	18.2
Sheboygan #1503	05/75	1 BC	F	4.5	0.3	0.3	0.3
Sheboygan Beach	07/75	3C, 1BR	F	12.9	9.5	12.0	28.0
Sheboygan Harbor	06/76	3WS	F	2.4	22	22	22
		2LT	F	12.2	7.9	16.5	25
		1CS	F	5.7	26	26	26
		5A, 3WF, 1BT, 1RT, 5BR, 1CN	F	5.9	2.4	6.2	12.0
10 mi. S.E. Sheboygan	04/77	30CH	WF	10.9	1.5	2.0	2.6
Port Washington	07/75	1RT, 2BT, 3BR, 4C	F	15.6	5.9	14.6	24.0
Port Washington Beach	07/75	7SM	F	5.8	0.6	2.0	5.1

TABLE 5.6-5 CONT'D

SITE	DATE	SPECIES SAMPLED	PORTION ANALYZED	% FAT	ppm PCB LOW	ppm PCB $\bar{x}$	ppm PCB HIGH
Grid #1803	05/77	5CH	EP	17.8	4.9	4.9	4.9
Grid #1805	05/77	22CH	EP	25.6	3.8	5.3	7.4
Whitefish Bay	05/77	9WF	F	16.8	1.0	2.0	3.3
Milwaukee #1901	05/72	10LT	EP	-	11.2	22.4	61.8
	05/75	6LT	F	9.2	3.2	6.8	11.8
		3BT, 1TT, 2CS	F	5.0	1.3	2.7	5.5
Grid #1903	05/77	20CH	EP	15.6	3.4	4.3	5.0
Grid #2203	05/77	15CH	EP	23.1	3.8	6.1	8.8
Milwaukee Reef	05/77	20CH	EP	16.2	2.4	3.7	4.4
Grid #2002 & 2003	05/75	2CH, 1BT	F	11.0	1.2	3.0	4.3
Strawberry Creek	11/74	12CN, 1CS	EP	2.4	1.8	9.1	17.0
	11/76	3CN	F	2.4	4.1	7.0	8.5
Sand Bay	06/76	2BU, 10YP, 10A	F	2.5	0.2	1.8	6.0
Sand Bay	04/77	9PR, 12BB, 6WS	F	1.1	0.3	2.2	5.1
Snake Island	06/76	15W	F	0.9	0.5	0.6	0.7
	04/77	10PK	F	0.9	0.7	2.8	6.4
		3YP, 20BU	F	1.6	.9	1.2	1.5
Chambers Island	02/75	4WF	EP	12.3	1.4	1.7	2.0
4 mi. S. Chambers Is.	02/75	4WF	EP	20.4	2.2	8.0	15.2
5 mi. S. Chambers Is.	02/75	4WF	EP	19.9	2.0	4.2	7.1
7 mi. S. Chambers Is.	07/71	14LT	EP	-	15.1	21.5	35.1
7 mi. S. Chambers Is.	02/75	6WF	EP	16.0	1.5	3.9	9.6
L. Sturgeon Bay	04/75	7C	EP	23.0	5.5	22.3	51.6
Sturgeon Bay	04/77	8W	F	2.5	0.5	1.5	2.3
Pt. Sable #1001	01/76	5NP	F	0.5	0.5	1.5	2.7
		4BU, 6WS, 4C, 1GS	F	2.5	0.9	5.2	13.3
Grid #1001	04/77	10WF	F	11.2	3.7	8.2	17.3
Dead Horse Bay	01/76	1WB	F	2.7	8.0	8.0	8.0
		3BB, 8YP	F	0.4	0.6	0.9	1.5
Grid #0804	06/75	3LT	F	2.9	10.0	11.8	14.9
		5YP	EP	2.9	3.2	4.4	5.6
	11/75	22LT,	11EP,10F	12.6	6.4	12.2	20.0

TABLE 5.6-5 CONT'D

SITE	DATE	SPECIES SAMPLED	PORTION ANALYZED	% FAT	ppm PCB LOW	ppm PCB $\bar{x}$	ppm PCB HIGH
Grid #0704	06/75	1CS	F	7.7	6.2	6.2	6.2
T30N R24E S16	08/76	6C	F	12.1	5.4	6.3	7.2
		3WF, 3NP, 3B, 5BU, 3CR. 10YP, 10P	F	3.5	0.0	1.4	1.9
Red Arrow Park	04/77	27SM	WF	4.2	2.5	2.7	3.1
	05/77	5YP	F	.5	.2	.2	.2
Off Pensaukee	08/76	9C	F	8.6	5.2	5.6	7.8
		3NP, 1SMB, 5BU, 2CR, 3P	F	1.0	0.5	1.0	2.4
Elm Marsh	04/77	1NP	F	1.0	3.6	3.6	3.6
Bel Ansul Chem	08/76	5C	F	12.0	4.6	12.5	20.3
		3W, 3NP, 3LMB, 5BU, 10PF, 10YP	F	3.8	0.2	4.1	3.3
Below DePere	05/77	4C	3WF,1F	4.5	2.5	25.9	90.0
		2W, 3NP, 6WS, 1BW,	F				
		19YP	15WF,9F	2.0	0.5	5.7	6.8
Neenah	05/77	25C	15WF,10F	4.8	2.7	18	5.0
		2W, 1NP	F	1.5	1.8	3.1	5.2
Lit. B. Des Mort	02/76	20YP	F	0.3	0.6	0.8	0.9
	06/76	11C	F	9.1	12.0	25.6	39.0
	08/76	8BU	F	6.0	5.2	9.4	13.6
		6WB	EP	4.9	9.3	9.6	9.8
		2S, 10W	F				
		10YP	5EP,5F	0.8	1.2	1.6	3.1
Butte Des Mort	06/76	6C	F	6.6	1.5	1.7	1.8
Lake Winnebago	08/74	29D	EP	12.9	0.2	0.3	0.4
Calumet Harbor	04/76	9SH	F				
& Lk Winnebago	06/76	6C	F	8.6	0.0	0.3	0.8
Eureka Dam	07/74	1LMB, 1WS, 1NP, 6C, 3R	EP	5.9	0.1	0.5	1.8
Lake Puckaway	06/76	12C	F	4.3	0.5	1.0	1.4
Gr. River Lock	07/74	1LMB	EP	3.0	6.7	6.7	6.7
		2BW, 1S, 1NP, 1D, 6C	EP	3.3	0.4	1.0	2.1
Buffalo Lake	07/75	2C	F	2.8	2.1	3.9	5.7
		1CR, 3B, 2SF, 3BU, 5YP, 2WS, 3NP		0.5	0.1	3.8	1.5
Ct. Tr. O. Bridge	07/74	1WS	EP	6.9	32.7	32.7	32.7
		2NP	EP	2.1	13.2	15.4	17.6

TABLE 5.6-5 CONT'D

SITE	DATE	SPECIES SAMPLED	PORTION ANALYZED	% FAT	ppm PCB LOW	ppm PCB $\bar{x}$	ppm PCB HIGH
Ct. Tr. O. Bridge (continued)	07/74	8C	EP	12.2	21.4	35.9	45.8
Co. Tk. O. Bridge	06/76	4WS	F	0.8	2.8	18.0	48.0
		3C	F	6.1	22.0	30.0	38.0
		6B, 4CR,	EP				
		4NP	F	4.0	3.7	7.7	9.8
		3RB, 2YP	WF				
		5BU	EP	2.0	19.0	30.5	50.0

* With reference to the letter code in Table 5.6-4, 1 CH implies that 1 chub (CH) was analyzed.

** W.F: whole fish
F: fillet
E.P: edible portion

TABLE 5.6-6

DDT AND PCB CONTENT OF EGGS FROM LAKE MICHIGAN LAKE TROUT

(Ref. 153)

Year	Average diameter (mm)	Concentrations (ranges for composite samples from 4 fish) DDT (ppm)	PCBs (ppm)
1973	5.2	2.74-5.24	5.33-9.90
1974	5.1	2.57-3.95	4.84-8.30
1975	5.1	1.41-3.55	3.16-6.33

TABLE 5.6-7

CHICAGO DEPARTMENT OF HEALTH
ANALYSES OF PCBS IN COMMERCIALLY AVAILABLE FISH FROM LAKE MICHIGAN

(Ref. 154)

Species	Portion Analyzed	Number Samples	PCB ppm Low	x	High
Coho Salmon	Whole (a)	29	0.3	2.5	6.7
	Fillet	24	0.1	1.4	4.3
Chinook Salmon	Whole (a)	13	1.0	6.1	10.1
	Fillet	14	0.4	3.7	7.7
Steel Head	Whole (a)	1		4.5	
	Fillet	1		1.2	
Brown Trout	Whole (a)	1		2.9	
	Fillet	1		1.7	
Perch	?	2	0.3	0.4	0.4

(a) Without head, tail and innards.

TABLE 5.6-8

ANALYSES FOR PCBS IN LAKE MICHIGAN FISH
PREPARED FOR HUMAN CONSUMPTION
(Ref. 127)

Species	Fishing Site	PCB Concentration (ppm) Raw	Cooked
Carp	Sturgeon Bay	16.3	13.7 (smoked)
Lake Trout	Grid 806	13.5	15.2 (boiled)
		3.3	3.9 (boiled)
		33.8	37.6 (boiled)
		5.9	5.7 (boiled)
		6.1	6.2 (boiled)
		4.8	4.8 (deep fry)
		3.0	3.0 (deep fry)
		2.9	3.1 (deep fry)
		5.7	6.6 (deep fry)
		7.1	8.0 (baked)
		5.4	6.9 (baked)
		3.1	3.7 (baked)
		4.8	5.0 (baked)
		4.3	4.8 (baked)
Lake Trout	Grid 706	14.0	13.8 (deep fry)
		6.0	5.7 (deep fry)

1976: Wisconsin Department of Natural Resources

TABLE 5.6-9

MERCURY CONCENTRATIONS IN LAKE MICHIGAN FISH TISSUE

Year	Location	Species	ppm Range	Mean $\pm$ S.E.	Source
1967-68	Lakewide	Alewife	0.49		56
		American Smelt	.10-.17	0.14 $\pm$ .01	
		Bloater	.13-.51	.25 $\pm$ .04	
		Deepwater Sculpin	.52-.96	.72 $\pm$ .07	
		Lake Trout	.11-.22	.19 $\pm$ .03	
		Lake Whitefish	.07		
		Quillback	.36-.75	.56 $\pm$ .20	
		Yellow Perch	.11-.14	.12 $\pm$ .02	
1970-71	Lake Michigan vicinity Door TWP and Kewaunee TWP	All species	.05-.70	.14	124
	Milwaukee River and Harbor	All species	.05-.35	.18	
	Green Bay	All species	.01-.75	.27	
	Menominee River	All species	.06-1.72	.43	
1970	Kewaunee	Brown trout		.11 (100% as methyl mercury)	124
1974	Whole Lake	Lake trout, salmon, Chub, Burbot	See Table 5.6-3		157

TABLE 5.6-10

(Ref. 125)

Arsenic, Cadmium, Chromium, Lead and Zinc Levels in Fish From Wisconsin Waters

Water	County	Site	Date	Sample Number	Species	Length (Inches)	Metal Levels in ppm Cr	Zn	Cd	As	Pb
Fox River	Racine	Below Burlington	5 Aug 1970	548	Sucker	14.6	–	–	0	–	0.28
				480	Sucker	16.0	–	–	0	–	0.75
				481	Redhorse	16.0	0	5.7	–	0	–
				483	Carp	–	–	–	–	–	0.32
				485	Carp			–	0	–	0.22
				488	2 Crappie		–	–	0	–	–
				484	White Bass	14.0	0.03	4.0	–	0	–
				476	Smallmouth Bass	17.3	–	4.7	–	0	–
				551	Channel Catfish	12.0	–	–	0	–	–
				552	Channel Catfish	12.0	–	–	0	–	0.35
Green Bay	Brown	E. of Fox River Mouth	5 Aug 1970	1,193	Carp	16.0	–	–	0	–	0.44
				1,194	Carp	16.0		–	0	–	0.46
				1,195	Carp	16.0		–	0	–	0.27
				1,191	Carp	18.0	0.07	8.8	–	–	–
				1,190	Carp	30.0	0.27	7.1	–	–	–
Green Bay	Door	N. of Sturgeon Bay Canal	5 Jun 1970	358	5 Sucker	14.7-18.5	–	–	–	–	0.12
				360	Lake Alewife	6.7-9.5	–	–	0	–	0.12
				363	Cisco	16.0	0	3.7	–	0.10	–
				359	3 Burbot	20.0-28.8	0	5.1	–	0.10	–
				356	Lake Trout	26.0	–	–	–	–	0.11
				355	Lake Trout	28.5	–	–	–	0.35	–
Lake Michigan	Kewaunee	E. of Kewaunee	1 Jun 1970	323	10 Alewife	5.6-8.0	–	–	–	–	0
				335	Rainbow Trout	17.7	–	–	0	–	0.25
				332	Brown Trout	18.5	–	–	0	–	0.25
				336	Brook Trout	17.3	0	3.2	–	0	–
				334	Coho Salmon	19.3	0	4.1	–	0.14	–
Lake Winnebago	Winnebago	Asylum Bay	23 Apr 1970	232	Freshwater Drum	13.5	–	–	0	–	0.05
				228	Freshwater Drum	14.0	–	–	0	–	0.05
				229	Freshwater Drum	17.0	0	4.1	–	0	–
				231	Freshwater Drum	17.0	–	–	–	0	–
				238	2 Crappie	11.0	–	–	0	–	0.05
				236	Crappie	11.0	–	–	0	–	0.05
				234	Crappie	11.0	0	4.6	–	0	–
				237	Northern Pike	12.0	0	4.8	–	0	–
				239	Northern Pike	20.0	–	–	0	–	0.94
Menominee River	Marinette	River Mouth	20 May 1970 and 15 Jun 1970	182	2 Sucker	14.0-18.0	–	–	0	–	0.07
				66	2 Sucker	20.0	–	–	0	–	0.18
				181	3 Bullheads	8.8-9.1	–	–	0	–	0.05
				69	3 Bullheads	8.5-10.0	–	–	0	–	0.05
				214	2 Sunfish	7.0	0.04	5.7	–	0	–
				176	Sunfish	7.5	0	4.8	–	–	–
				215	Largemouth Bass	14.5	0	3.7	–	0	–
				185	Largemouth Bass	16.0	0	4.1	–	0.12	–
Milwaukee River	Milwaukee	Above North Ave.	9 Jul 1970	418	8 Goldfish	10.0	0	18.3	–	0.10	–
				417	3 Carp	10.0-13.0	–	–	0	–	0.30
				416	Carp	14.0	–	–	0	–	0.27
				415	Carp	16.0	–	–	–	0	–
Milwaukee River	Milwaukee	Milwaukee Harbor	20 May 1970 and 25 May 1970	18	Sucker	–	0.42	6.9	–	0	–
				22	3 Sucker	–	–	–	0	–	–
				17	2 Coho Salmon	18.0-20.0	0	4.6	–	0	–
Milwaukee River	Ozaukee	Above Thiensville	8 Jul 1970	407	4 Sucker	10.0-14.0	0	4.8	–	0	–
				408	4 Sucker	11.0-12.0	0	4.7	–	0	–
				409	Carp	15.0	–	–	0	–	0.05
				410	Carp	17.0	–	–	0	–	0.30
				411	Carp	18.0	0	10.6	–	0	–
				414	Northern Pike	15.0	–	–	0	–	0.06
				412	Northern Pike	17.0	0	4.2	–	0	–
				413	Northern Pike	17.0		–	0	–	0.05

5.7 DATA ON WILDLIFE

Table 5.7-1 summarizes the results of studies on organic contaminant levels in Lake Michigan wildlife. Of particular interest are the results of J. J. Hickey (159) which were reported by S. J. Kleinert at the Joint Hearing of the Assembly Environmental Quality Committee with the Senate and Assembly Natural Resources Committees on NR 212 Administration Rules for PCB Effluent Standards in Semptember 1976 (127). Analyses were made of sediments, insects, fish, herring gull adults, chicks and eggs, merganser and heron in Green Bay, and the results are reported in Table 5.7-2. Very high levels of PCBs are noted in fish eating birds such as the merganser. Herring gulls which died in tremors also had very high levels of PCBs.

Also in 1970, the Wisconsin Department of Natural Resources analyzed deer, rabbit, grouse, pheasants, several species of ducks and geese for mercury contamination (124). The results are shown in Table 5.7-3. Also the table contains the results of the study by Peterson and Ellarson (160), whereby 100 old squaw (an amphipod eating duck) livers were analyzed for mercury.

TABLE 5.7-1

ANALYSES FOR ORGANIC CONTAMINANTS IN LAKE MICHIGAN WILDLIFE

mg/kg fresh weight

DATE	SAMPLING SITE	NO. SAMPLES	SPECIES	PORTION ANALYZED	MIREX	DDE	DDD	DDT	DIEL-DRIN	HEPTA-CHLOR EPOXIDE	BHC	HCB	OXY-CHLOR-DANE	PCBs	PCBs AROCLOR 1260	PHOTO MIREX	SOURCE
1973	Green Bay See Table 5.7-2	-	Insects, Birds, Eggs											✓			127, 159
1974	Grand Traverse Co.		Star-lings			0.27		0.02	TR	0.005	TR	TR	0.01	0.33			72
1974	Kent County		Star-lings			0.29		0.02	TR	0.01	0.02	TR	0.01	0.17			72
1974 1975		10	Herring gulls	Eggs	TR (TR-2.5)	32 (16-145)	TR	0.13 (.07-.39)	0.5 (.3-.9)	0.2 (.1-.6)		0.04 (.02-.14)		91 (55-395)			73
1977	Hat Island	9	Herring gulls	Eggs	.21 (±.29)	28 (±9)	.21 (±.02)	.16 (±.05)	.72 (±.60)		.03 (±.03)	.12 (±.09)			97 (±31)	.09 (±.10)	74
1977	Little Sister Island	10	Herring	Eggs	.07 (±.04)	31 (±13)	.26 (±.07)	.18 (±.12)	.65 (±.21)		.02 (±.01)	.13 (±.05)			90 (±27)	.04 (±.02)	74

TABLE 5.7-2

(Ref. 127)

Preliminary residue data-Green Bay ecosystem, 1973-74.(1)

Specimen	No. of pools analyzed	No. of individuals per pool	mg/kg fresh weight Mean PCB(2) Est. 1254	Est. 1248
Bottom muds-1973(3)	3	-	.026	ND(4)
Pontoporeia-1973	1	281	.58	ND
Insects-Coleoptera-1974	1	131	.091	ND
Fish-1974				
Smelt	1	75	1.62	4.49
Lawyer	1	5	1.56	3.68
Alewives	1	17	.96	1.61
Whitefish				
Fillet	1	5	.84	2.72
Viscera	1	10	9.01	3.71
Lake Trout Fillets	1	5	7.23	11.6
Herring Gull Adults				
Collected-1973-Breast Muscle(5)	3	3-4	180	24.9
Collected-1974 Breast Muscle	10	1	118	41.2
Died in Tremors-1973 Brain	3	1	304	134
Herring Gull Chicks				
Collected-1973 Breast Muscle	1	5	9.06	10.1
Collected-1974 Breast Muscle	1	5	6.39	5.56
Died in Tremors-1974 Whole Body	1	3	442	154
Red-breasted Merganser Eggs-1973	1	3	260	52.5
Black-crowned Night Heron Eggs-1973	3	3-4	57.3	39.1
Ring-billed Gull Eggs-1974	3	4	84.1	30.7
Herring Gull Eggs				
Green Island-1973	1	10	169	52.1
Green Island-1974	1	10	198	6.67
Apostle Islands Lake Superior-1974(6)	1	15	333	49.3

TABLE 5.7-2 CONT'D

Specimen	No. of pools analyzed	No. of individuals per pool	Mean PCB(2) Est. 1254	Mean PCB(2) Est. 1248
Sister Islands				
Addled eggs-1973	1	10	463	74.1
Addled eggs-1974	1	10	421	77.7
Cracked eggs-1973	1	19	347	68
Cracked eggs-1974	1	15	322	67
Renest eggs-1973(6)	1	10	71.1	71.1
Random Collection-1971	3	4	178	39.8
Random Collection-1972	3	3-4	309	73.1
Random Collection-1973	3	3-4	349	107
Random Collection-1974	3	4	249	74.2

(1) All residues expressed as ppm wet-weight basis.

(2) Where more than one pool was analyzed, the means are weighted for the sample size of each pool.

(3) Residue data must be considered unreliable because Na_2SO_4 contamination was approximately equal to this value.

(4) ND = Not Detected

(5) These data are suspect because of one extremely low sample and must be rechecked.

(6) Data suspect-sample number switch suspected. Samples will be rechecked.

TABLE 5.7-3

ANALYSES FOR MERCURY IN LAKE MICHIGAN WILDLIFE

(Ref. 124, 160)

Date	Sampling Site	No. of Samples	Species	Tissue Analyzed	ppm wet weight	Source
1970	Kenosha County	2	White-tailed deer (Mature Male)	Muscle Liver	0.01 0.01	124
1970	Marinette County	1	White-tailed deer (Mature Female)	Muscle Liver	T T	
1970	Kenosha County	1	Cottontail rabbit	Muscle Liver	T T	
1970	Marinette County	1	Cottontail rabbit	Muscle Liver	T 0.01	
1970	Marinette County	2	Ruffed grouse	Muscle	0.01	
1970	Kenosha County	1	Ring-necked pheasant	Muscle Liver	T 0.01	
1970	Bayfield County	1	Mallard duck	Muscle Liver	0.02 0.14	
1970	Bayfield County	1	Wood duck	Muscle Liver	0.01 0.03	
1970	Douglas County	1	Wood duck	Muscle Liver	0.19 0.35	
1970	Green Lake County Grand River Wildlife Area	1	Green-winged teal	Muscle Liver	0.05 0.13	
1970	Green Lake County Grand River Wildlife Area	1	Mallard	Muscle Liver	0.02 0.10	
1970	Green Lake County Grand River Wildlife Area	2	Shoveler	Muscle Liver	0.4, 0.2 1.0, 0.5	
1970	Manitowoc County	1	Blue-winged teal	Muscle Liver	0.29 0.85	
1970	Manitowoc County	1	Mallard	Muscle Liver	0.10 0.39	
1970	Winnebago County	1	Mallard	Muscle Liver	0.16 0.37	

TABLE 5.7-3 CONT'D

Date	Sampling Site	No. of Samples	Species	Tissue Analyzed	ppm wet weight	Source
1970	Winnebago County	1	Wood duck	Muscle Liver	0.08 0.05	
1970	Bayfield County	1	Bufflehead	Muscle Liver	0.12 0.53	
1970	Bayfield County	1	Canvasback	Muscle Liver	0.01 0.04	
1970	Bayfield County	1	Lesser scaup	Muscle Liver	0.12 0.43	
1970	Big Green Lake	1	Goldeneye	Muscle Liver	0.35 0.84	
1970	Big Green Lake	1	Lesser scaup	Muscle Liver	0.60 0.20	
1970	Big Green Lake	1	Ringneck	Muscle Liver	0.02 0.01	
1970	Grand River Wildlife Area	1	Ringneck	Muscle Liver	0.03 0.01	
1970	Milwaukee County (Lake Michigan)	1	Bufflehead	Muscle Liver	0.16 0.73	
1970	Milwaukee County (Lake Michigan)	1	Goldeneye	Muscle Liver	0.13 0.44	
1970	Milwaukee County (Lake Michigan)	1	Lesser scaup	Muscle Liver	0.31 1.01	
1970	Milwaukee County (Lake Michigan)	1	Old squaw	Muscle Liver	0.15 0.78	
1970	Oconto County	1	Goldeneye	Muscle Liver	0.24 1.23	
1970	Oconto County	1	Lesser scaup	Muscle Liver	0.08 0.25	
1970	Milwaukee County	1	American coot	Muscle Liver	0.08 0.35	
1970	Grand River Wildlife Area	2	Canada goose	Muscle Liver	0.01 0.01, 0.02	
1970	Grand River Wildlife Area	1	Snow goose	Muscle Liver	0.01 0.01	
1970	Grand River Wildlife Area	1	Blue goose	Muscle Liver	0.02 0.01	

TABLE 5.7-3 CONT'D

Date	Sampling Site	No. of Samples	Species	Tissue Analyzed	ppm wet weight	Source
1970	Waukesha County	1	Canada goose	Muscle Liver	0.01 0.02	
1970	Grand River Wildlife Area	2	Pied-bill grebe	Muscle Liver	0.5, 0.5 1.5, 1.9	
1970 1971	Lake Michigan	100	Old squaw	Liver	0.74 (0.23-3.19)	160

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ABBREVIATIONS AND CHEMICAL SYMBOLS USED IN THIS REPORT

Abbreviations

BHC:	Benzene hexachloride. The γ isomer is also called lindane.
DBP:	Dibutyl phthalate
DDE:	1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene
DDT:	Dichlorodiphenyltrichloroethane
DEP:	Diethyl phthalate
DEHP:	Di(2-ethylhexyl)phthalate
EP:	Edible portion (in reference to fish samples)
F:	Fillet (in reference to fish samples)
GLECS:	Great Lakes Environmental Contaminant Survey
HCB:	Hexachlorobenzene
HCBD:	Hexachlorobutadiene
HEOD:	Hexachloro-epoxy-octahydro-dimethanonapthalene. (Commonly known as dieldrin)
ng:	nanogram (one billionth of a gram)
PAH:	Polyaromatic hydrocarbon
PBB:	Polybrominated biphenyl
PCB:	Polychlorinated biphenyl
PCT:	Polychlorinated terphenyl
ppb:	parts per billion (nanograms per gram)
ppm:	parts per million (micrograms per gram)
SD:	Standard deviation
TDE:	Tetrachlorodiphenylethane, also referred to as: DDD
TFM:	3-trifluoromethyl-4-nitrophenol
TWP:	Township
WTP:	Water treatment plant
WWTP:	Wastewater treatment plant

Chemical Symbols

Ag:	Silver	Mo:	Molybdenum
As:	Arsenic	Ni:	Nickel
Cd:	Cadmium	Pb:	Lead
Co:	Cobalt	Se:	Selenium
Cr:	Chromium	Sr:	Strontium
Cu:	Copper	V:	Vanadium
Mg:	Mercury	Zn:	Zinc